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Pannu et al.

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(54) **MOLDS, MOLD ASSEMBLIES AND STACK COMPONENTS**

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B29B 11/08 (2006.01)

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CPC **B29C 45/7312** (2013.01); **B29B 11/08** (2013.01); **B29C 33/301** (2013.01); (Continued)

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See application file for complete search history.

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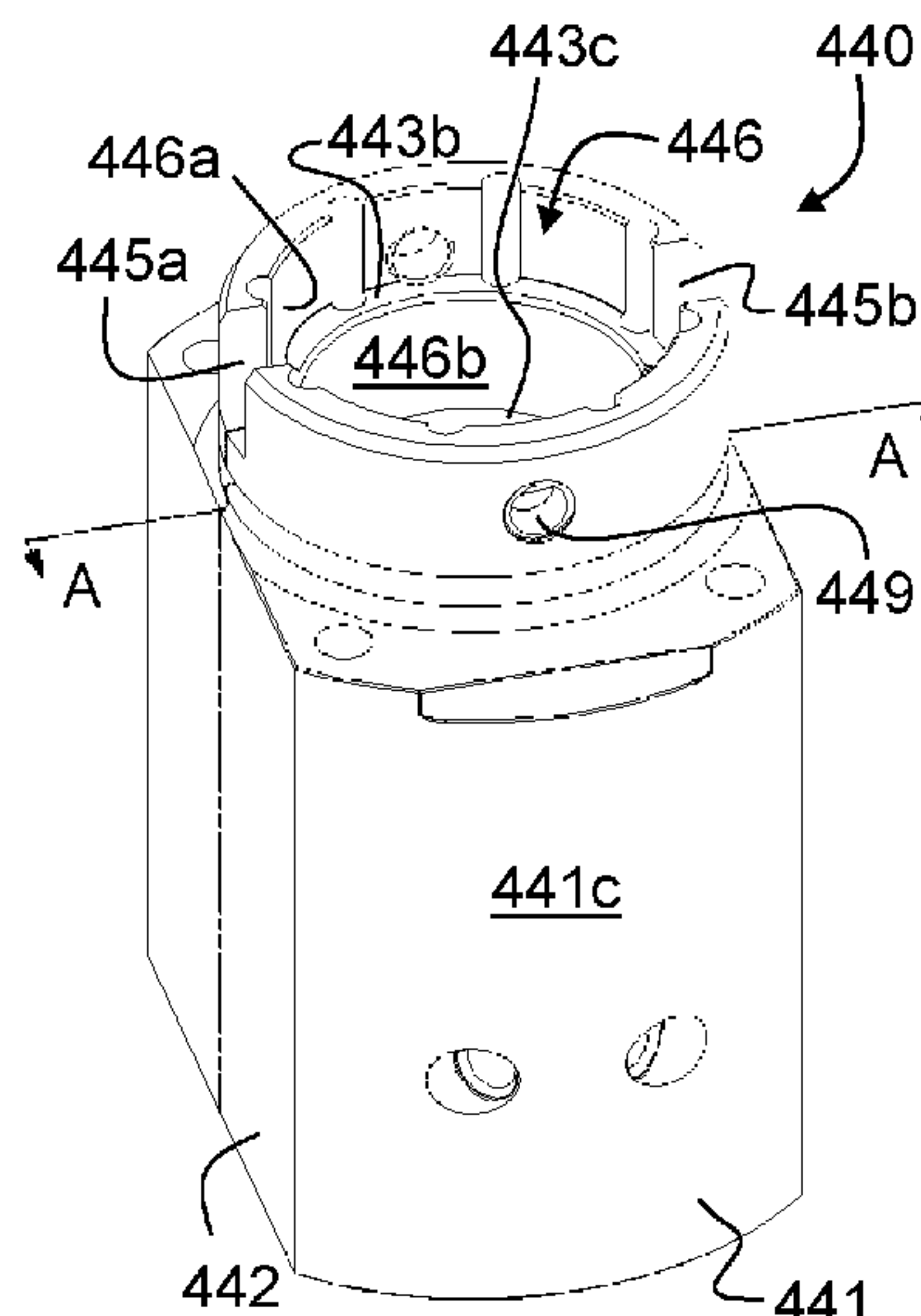
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Primary Examiner — Benjamin A Schiffman

(57) **ABSTRACT**

A cavity plate assembly (400) for a preform mold (100), which includes a cavity plate (410) having an array of seats (412) and a corresponding array of cavity inserts (440) mounted to a front face (CVF) of the cavity plate (410) and in communication with a respective seat (412). Each cavity insert (440) includes a body (441) with a mounting face (441a) and a spigot (443) projecting from the mounting face (441a) and received in a respective seat (412) of the cavity plate (410) such that the mounting (441a) face abuts the front face (CVF) of the cavity plate (410). Each cavity insert (440) also includes a molding surface (448) along its length, at least two thirds of which extends beyond the cavity plate (410).

10 Claims, 19 Drawing Sheets



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B29C 45/26 (2006.01)
B29C 45/27 (2006.01)
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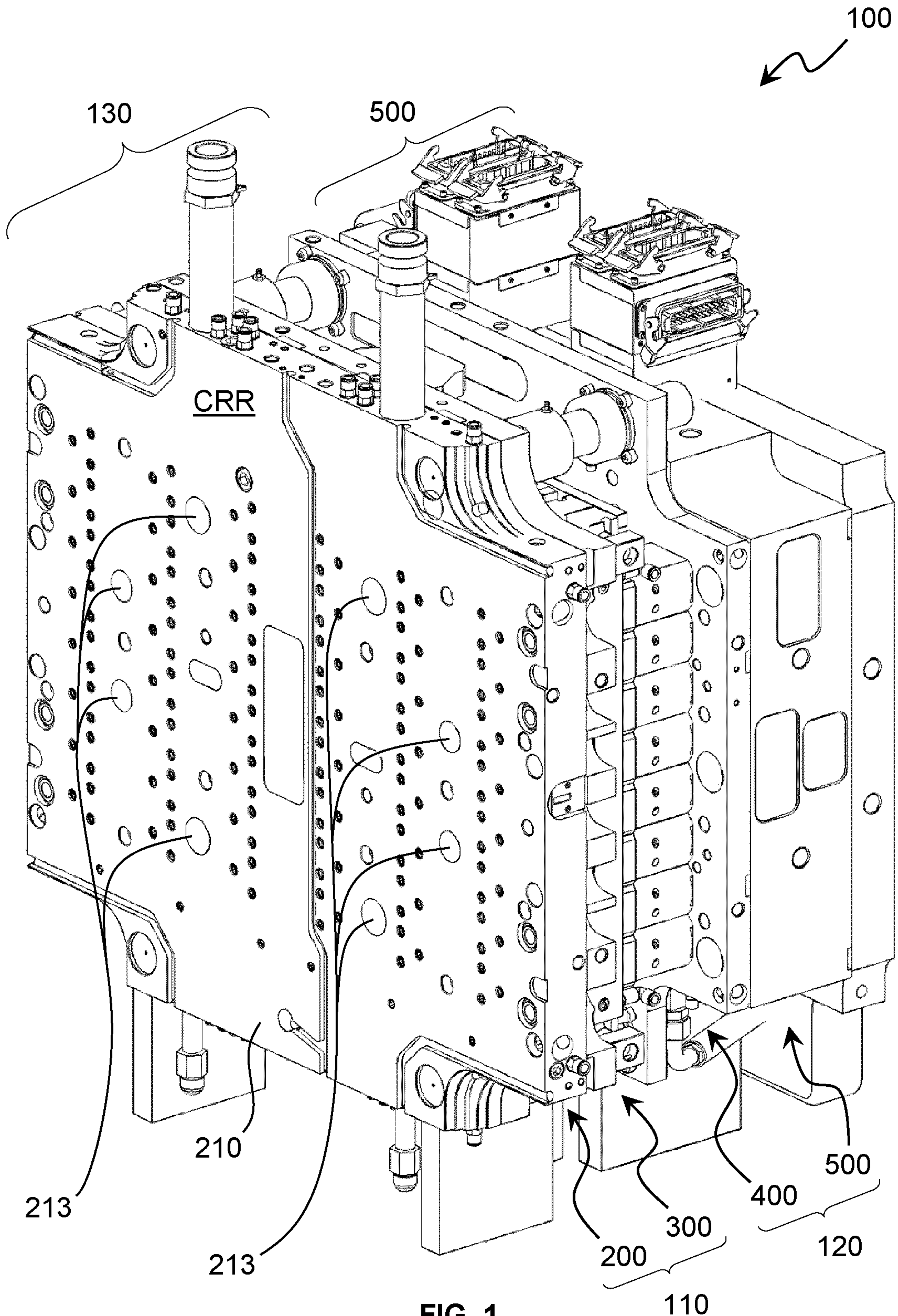
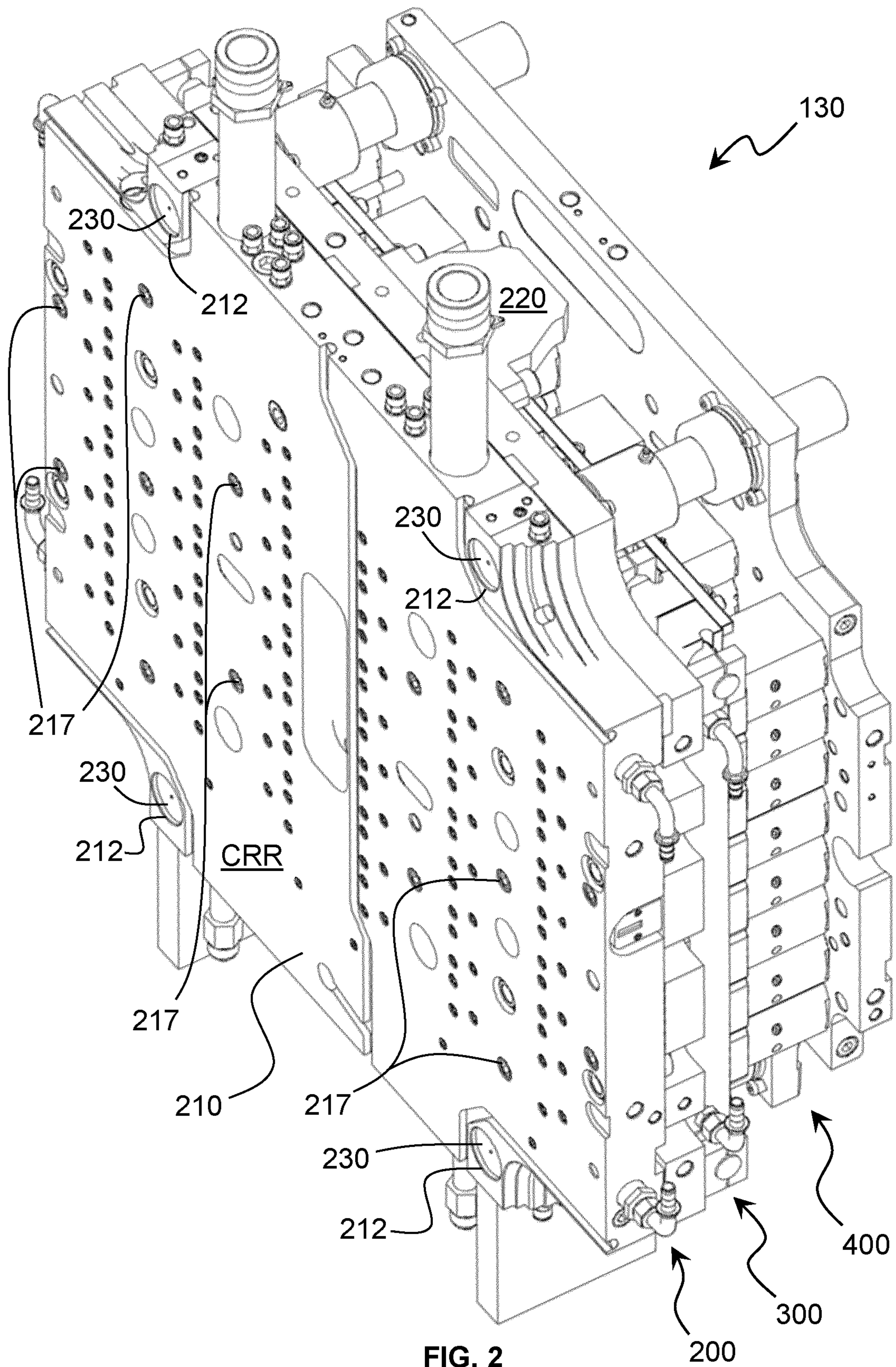


FIG. 1

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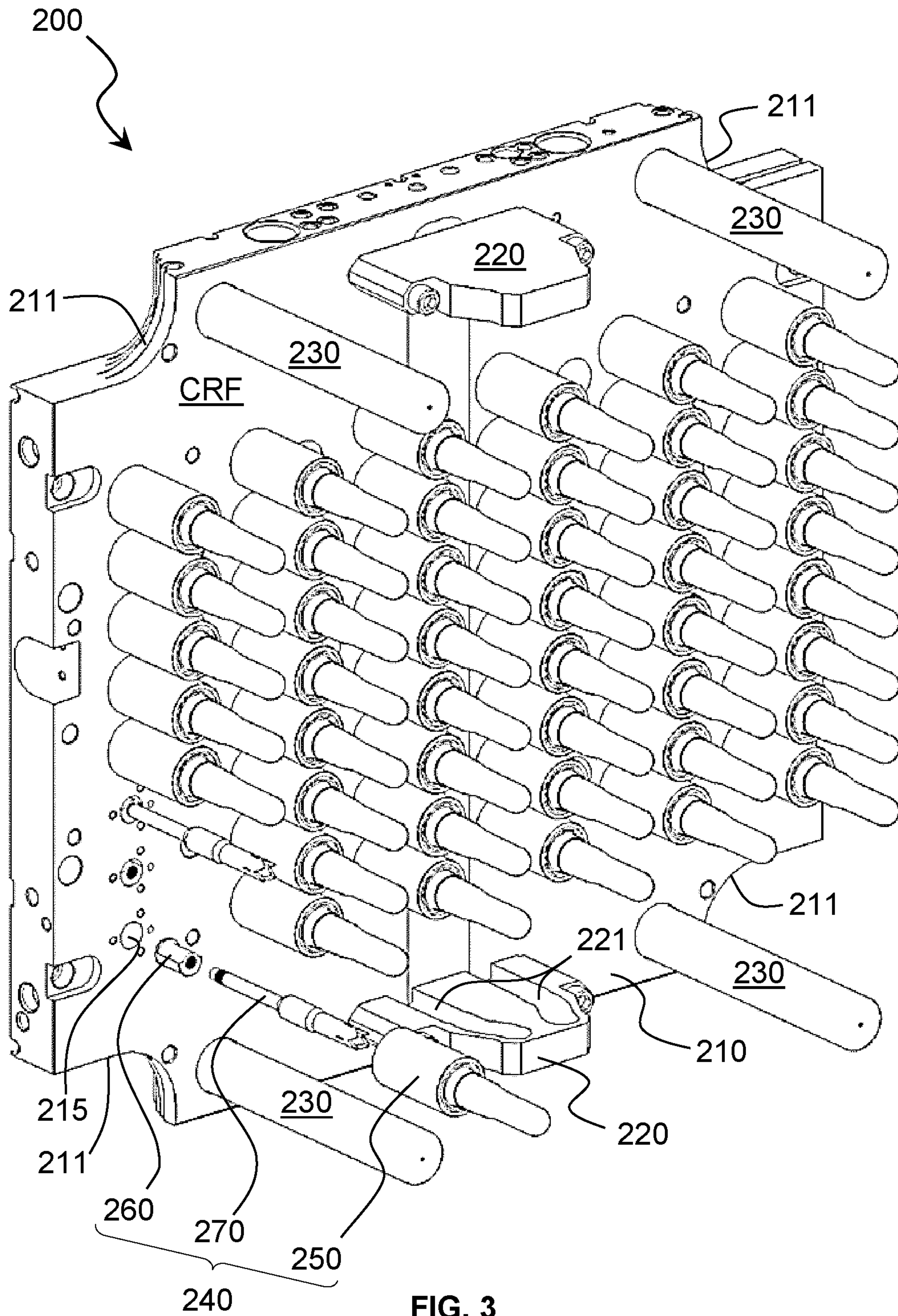


FIG. 3

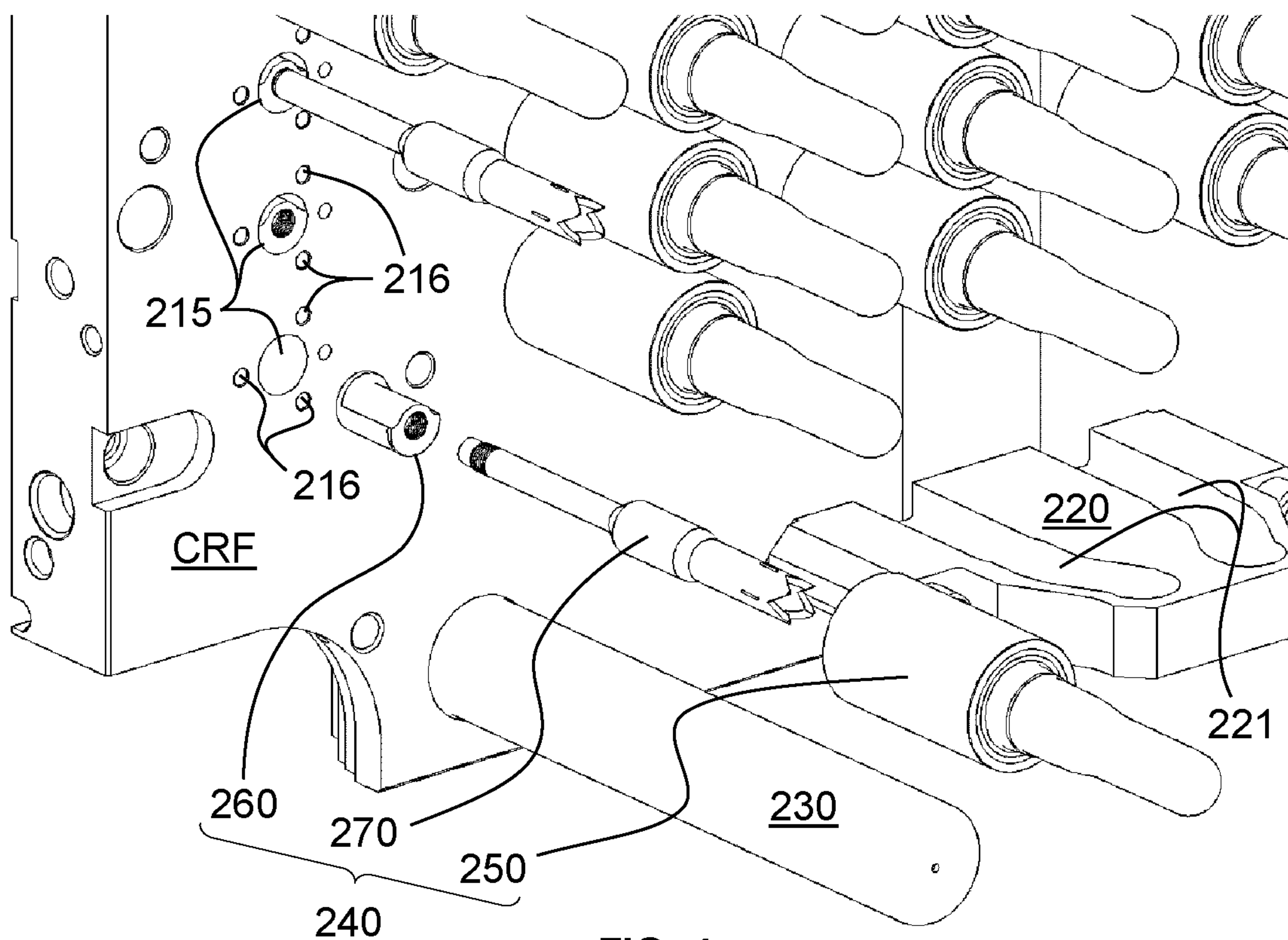


FIG. 4

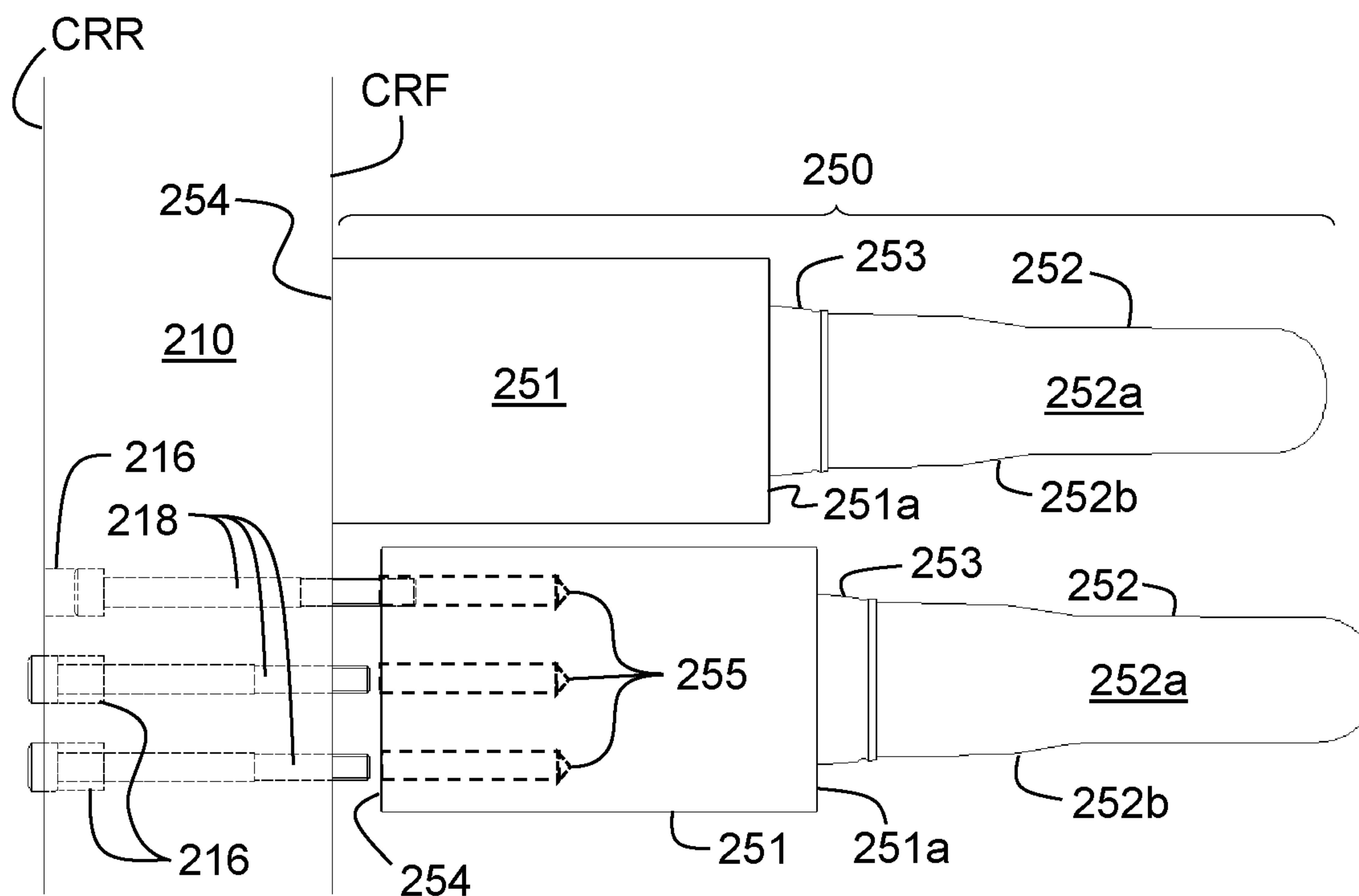


FIG. 5

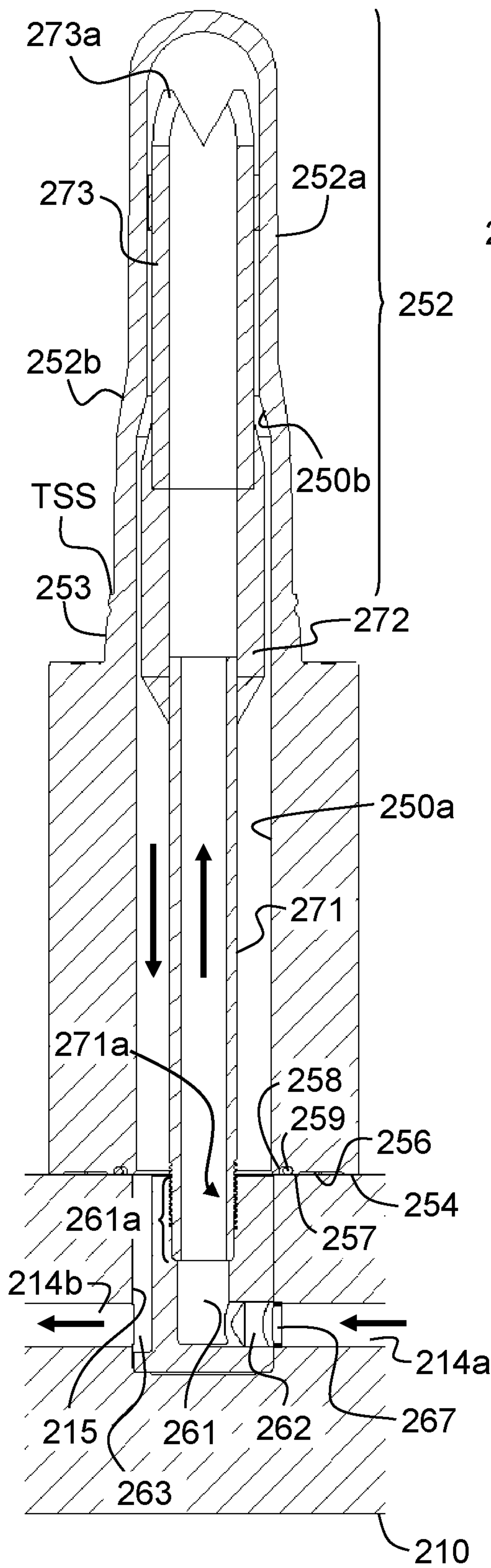


FIG. 6

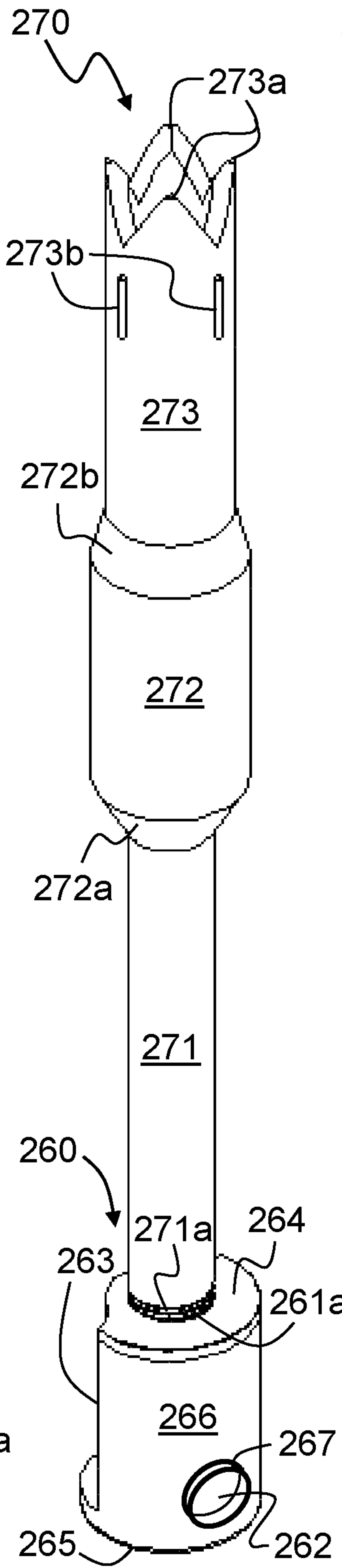


FIG. 7

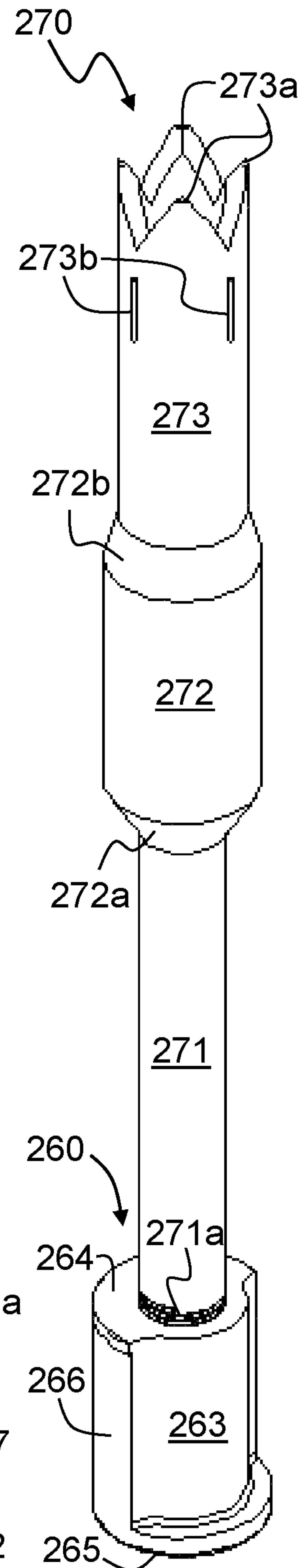


FIG. 8

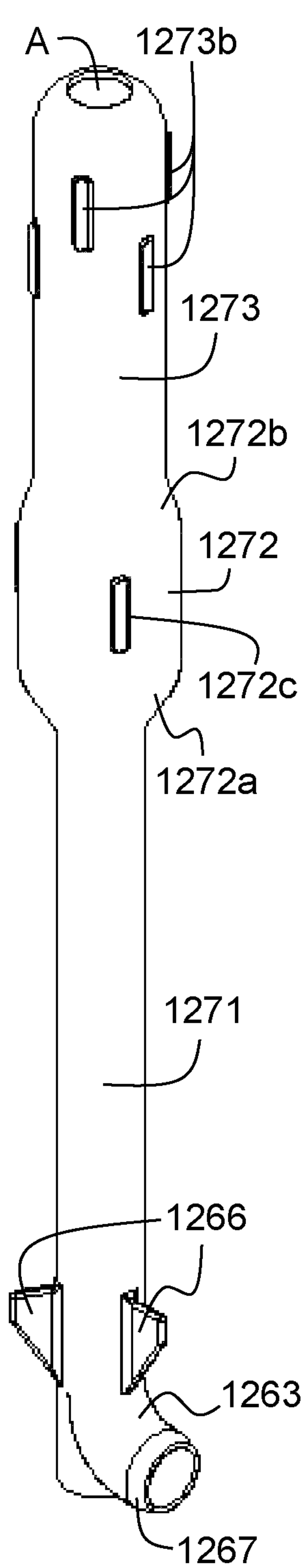


FIG. 9

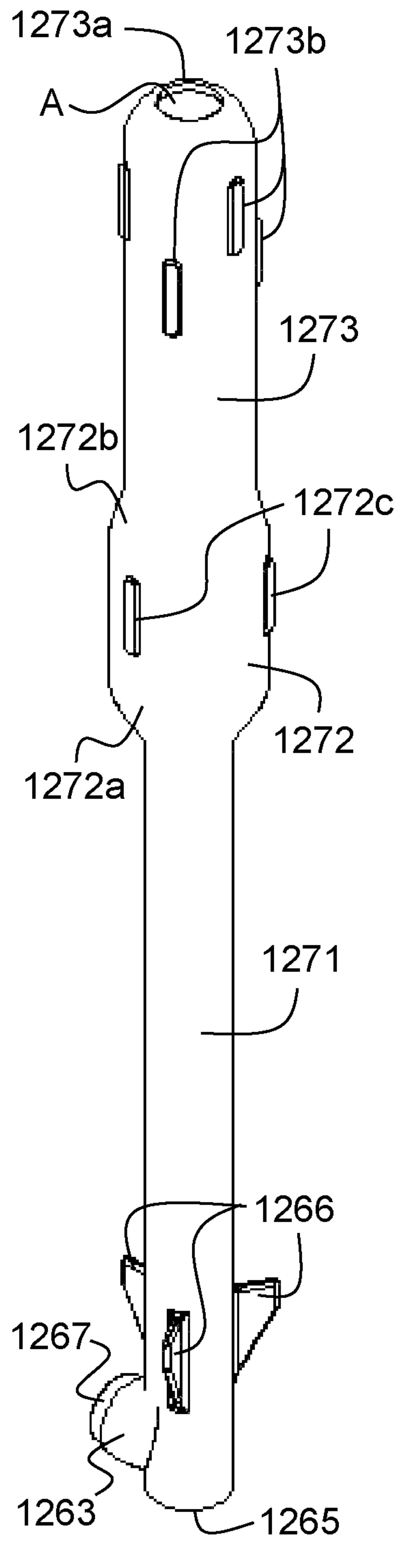


FIG. 10

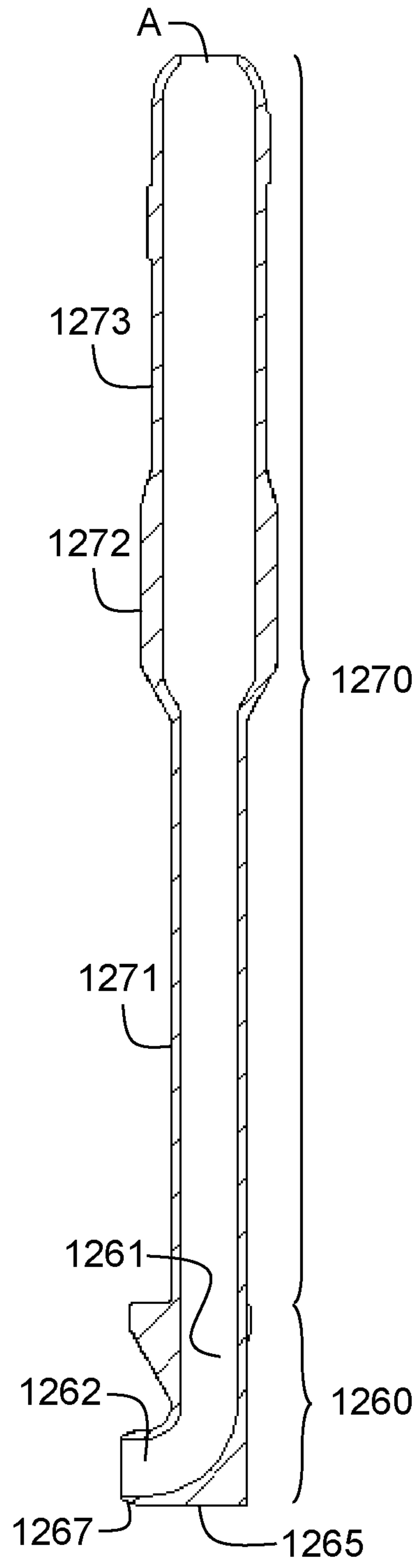


FIG. 11

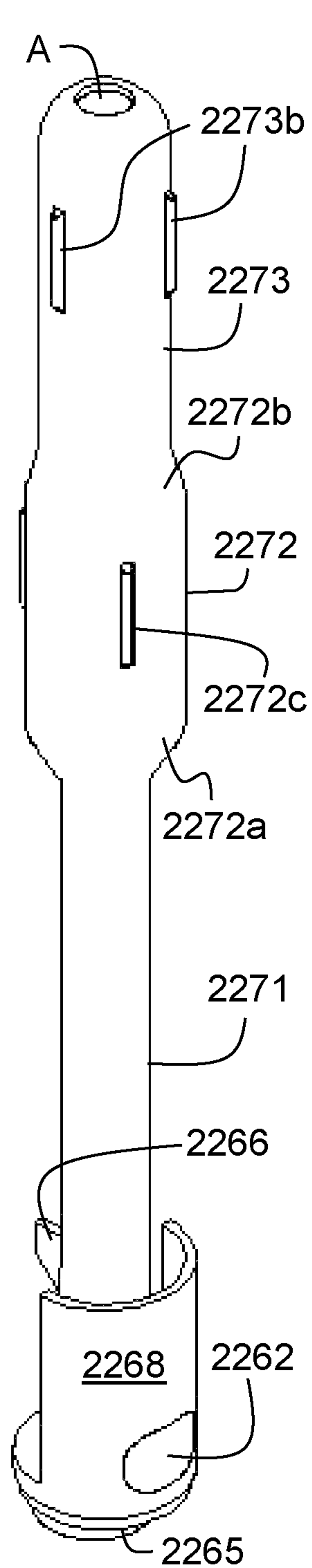


FIG. 12

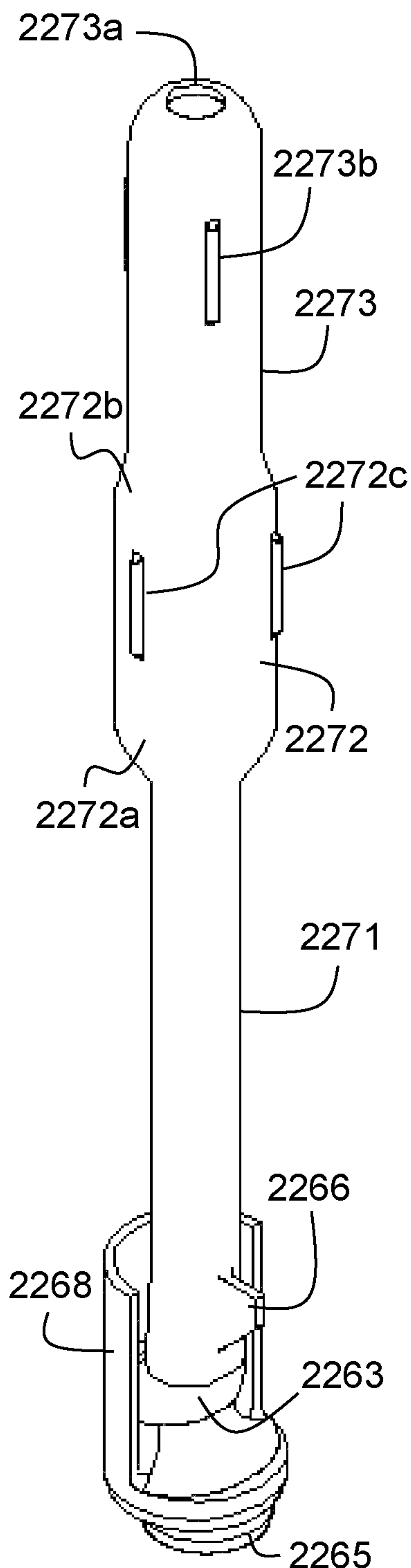


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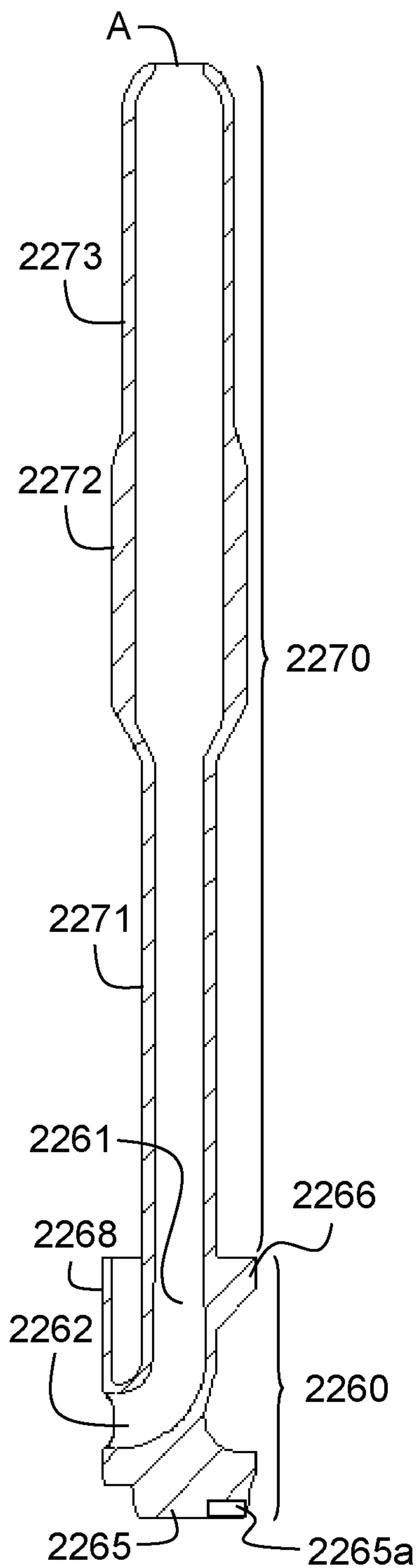


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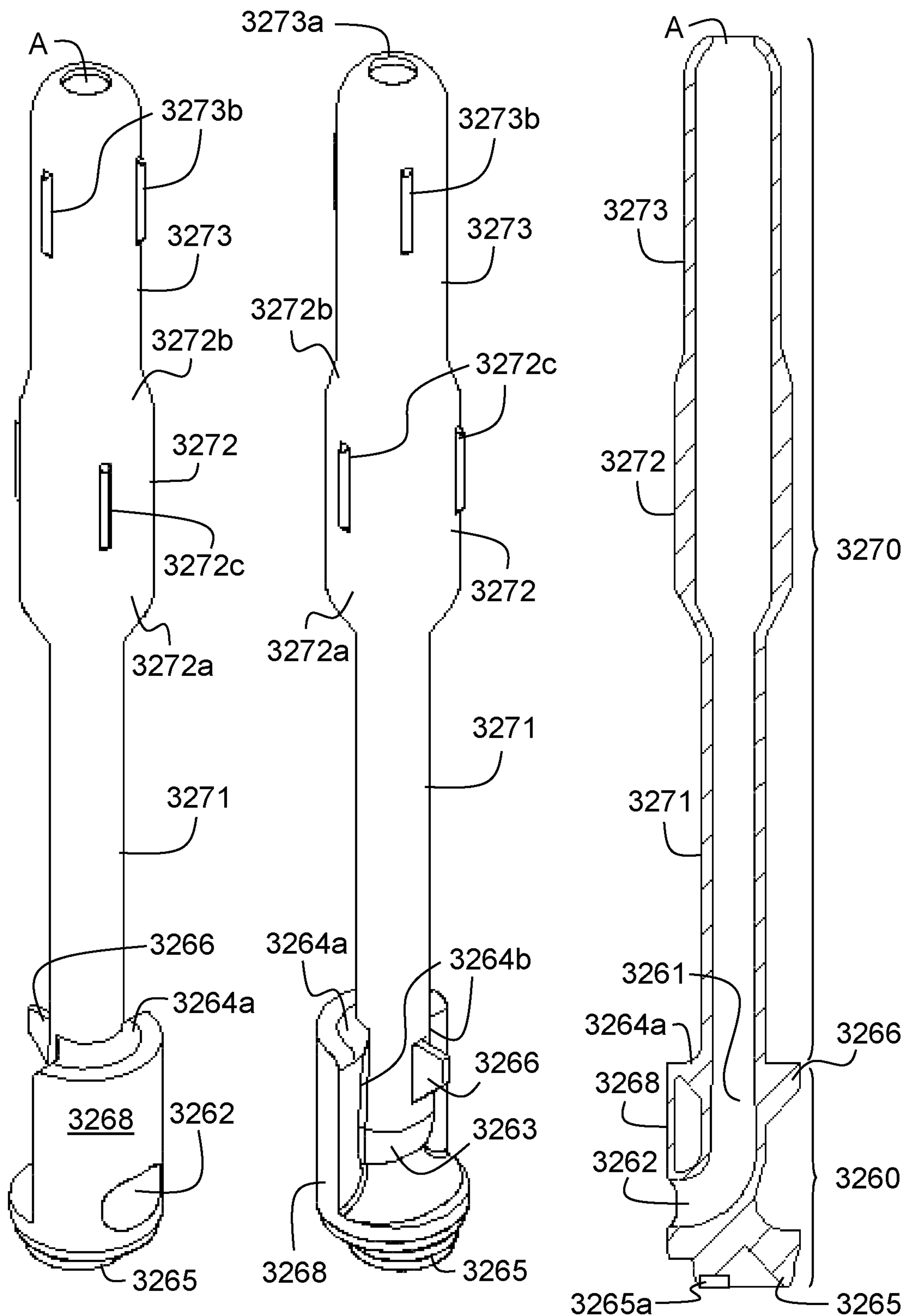


FIG. 15

FIG. 16

FIG. 17

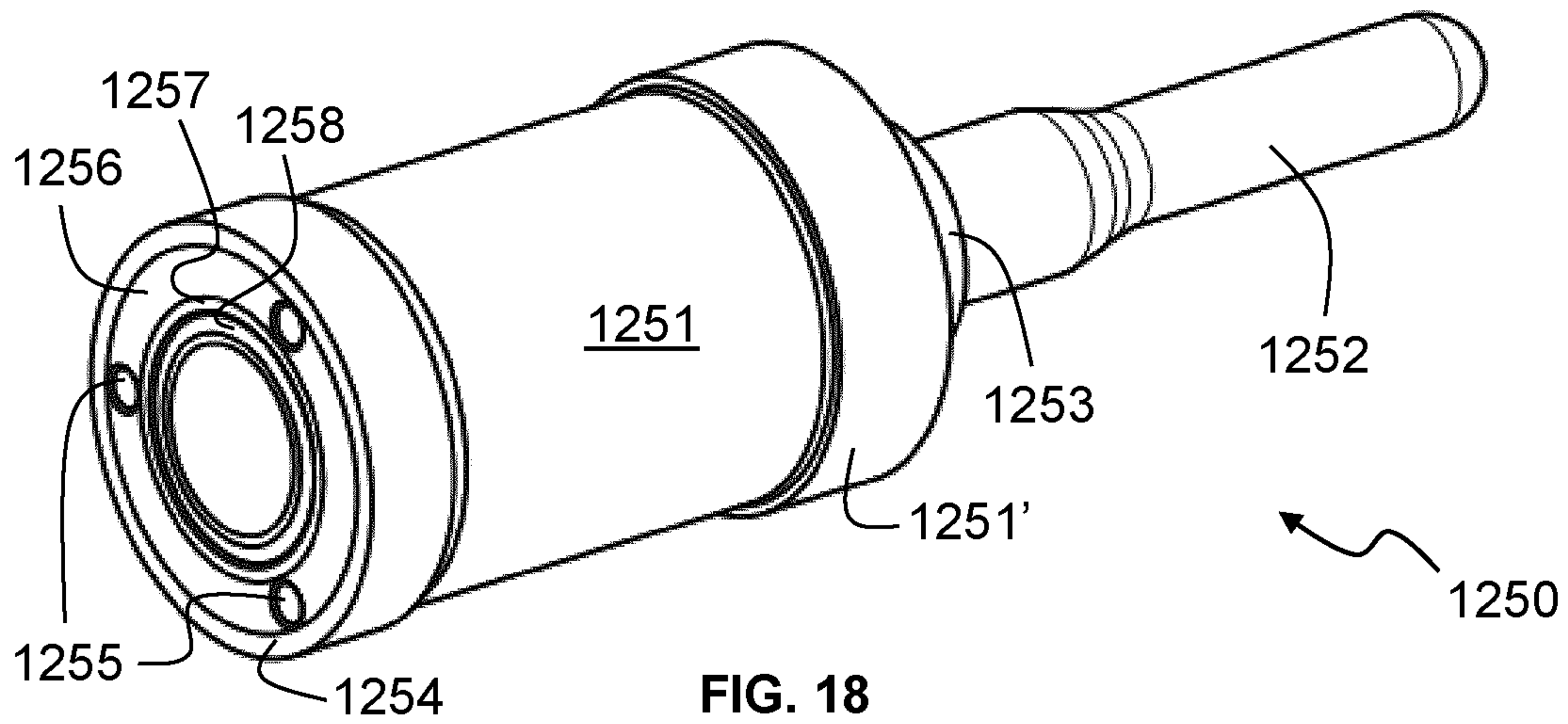


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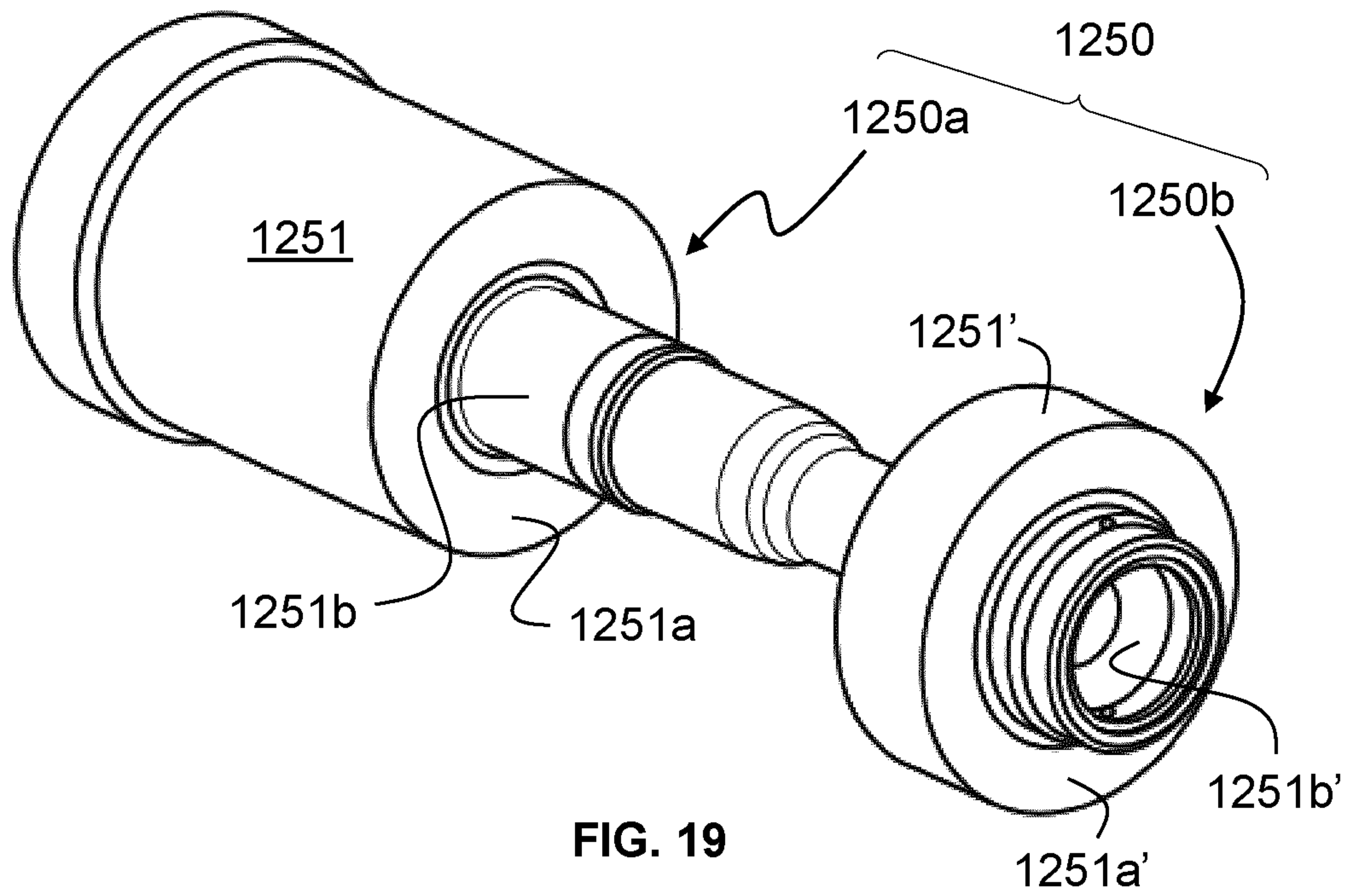


FIG. 19

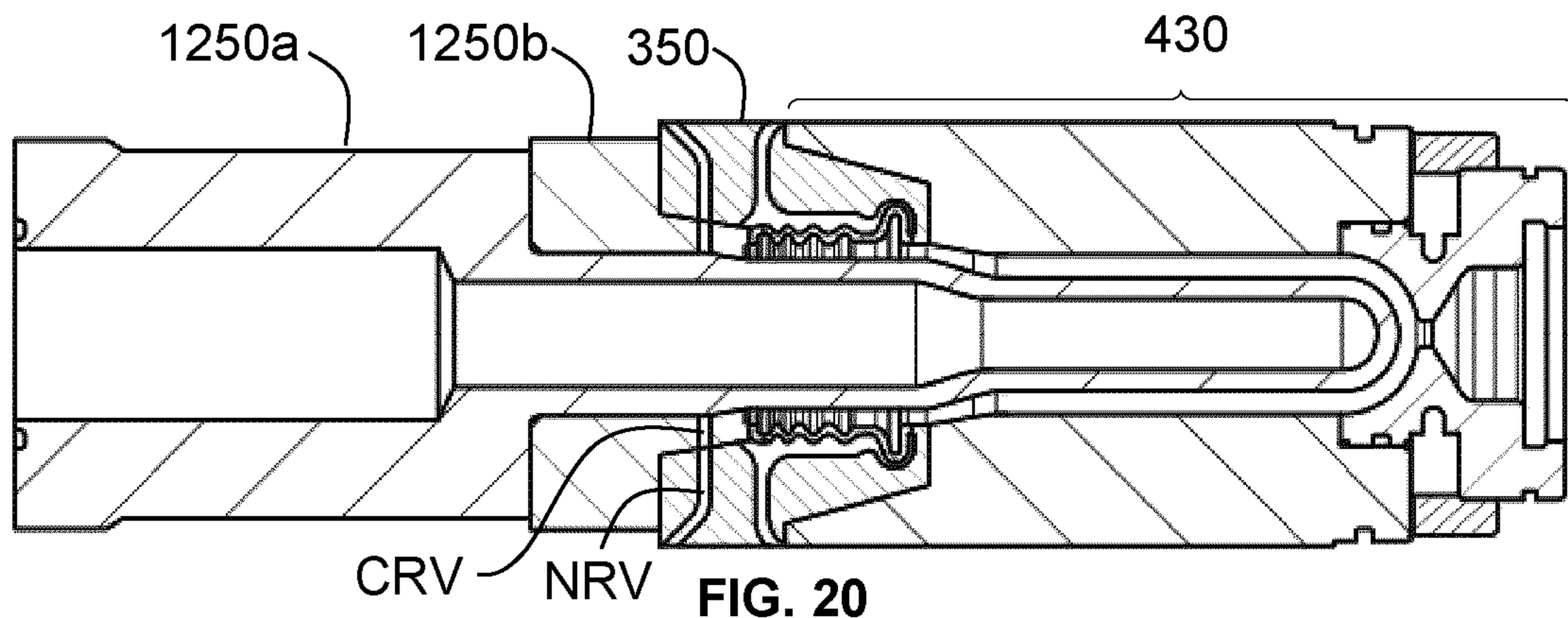


FIG. 20

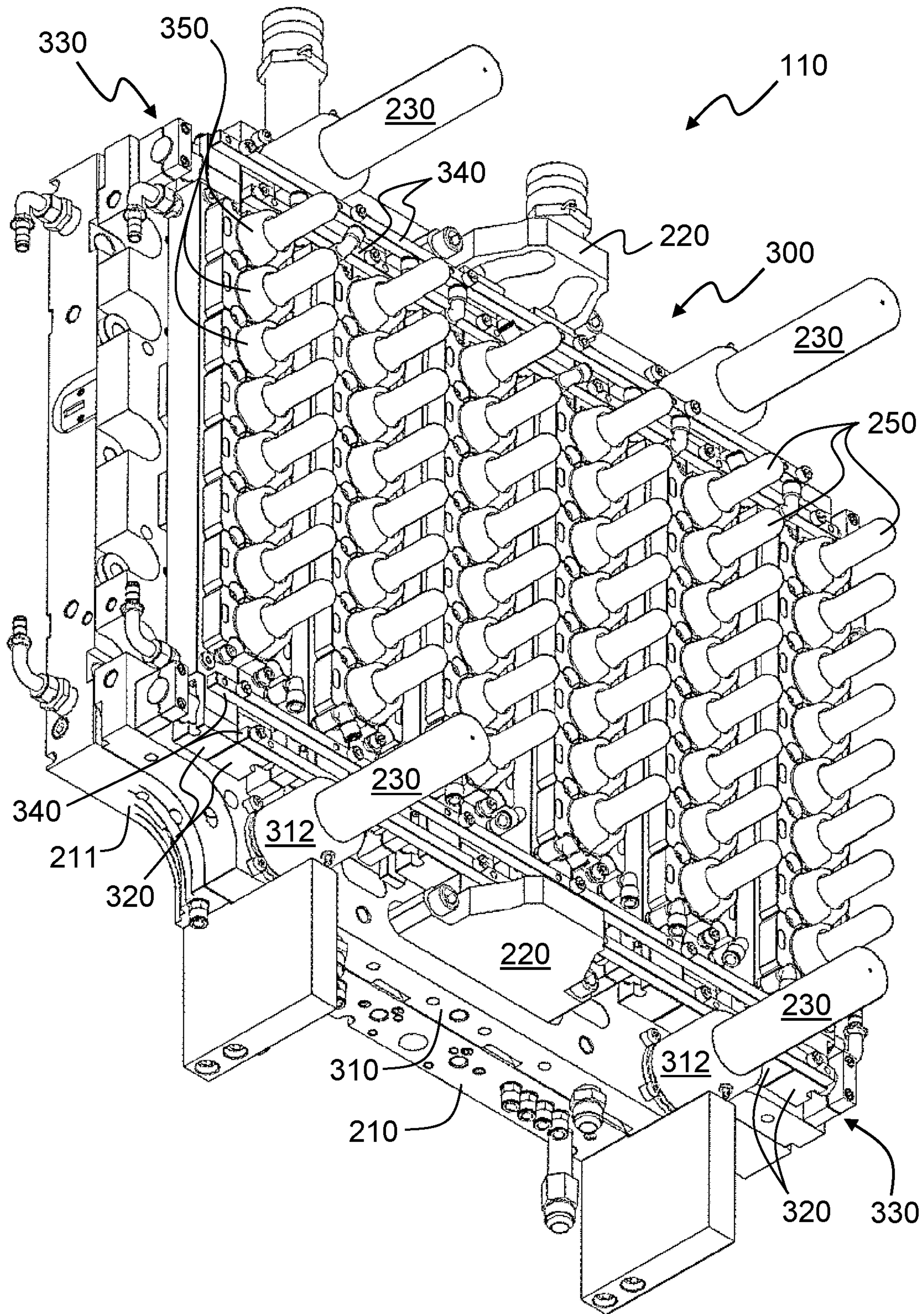


FIG. 21

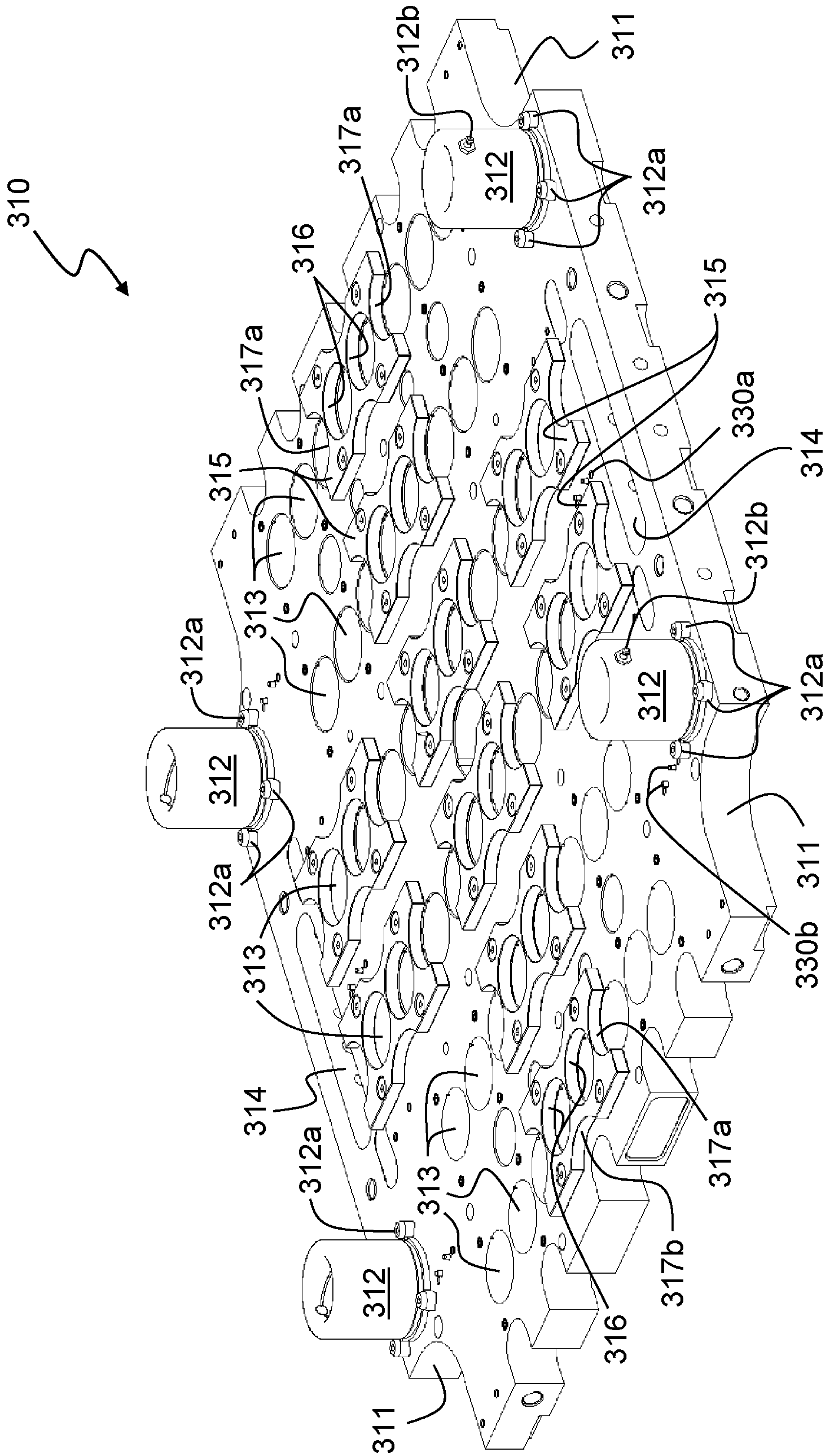


FIG. 22

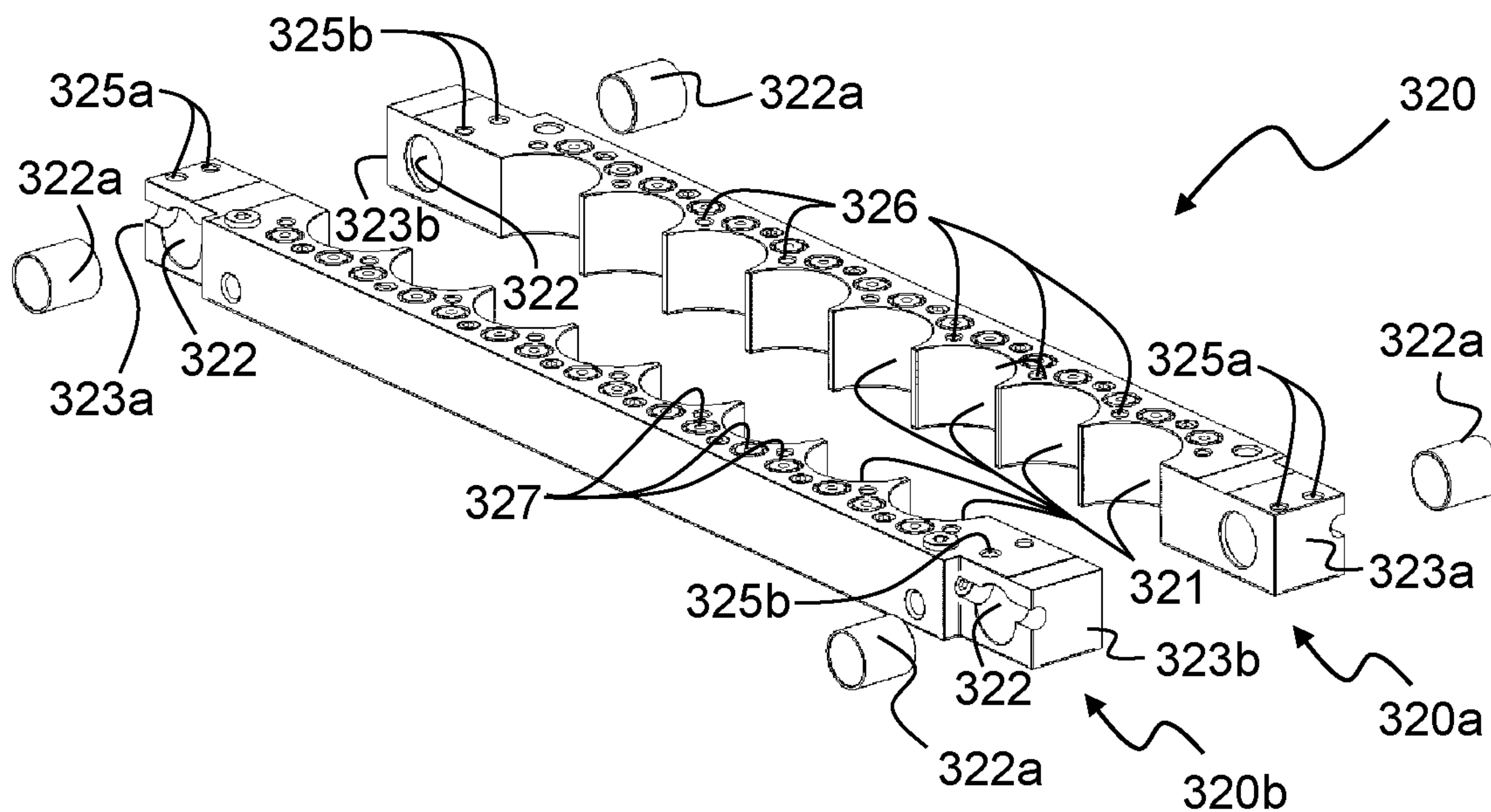


FIG. 23

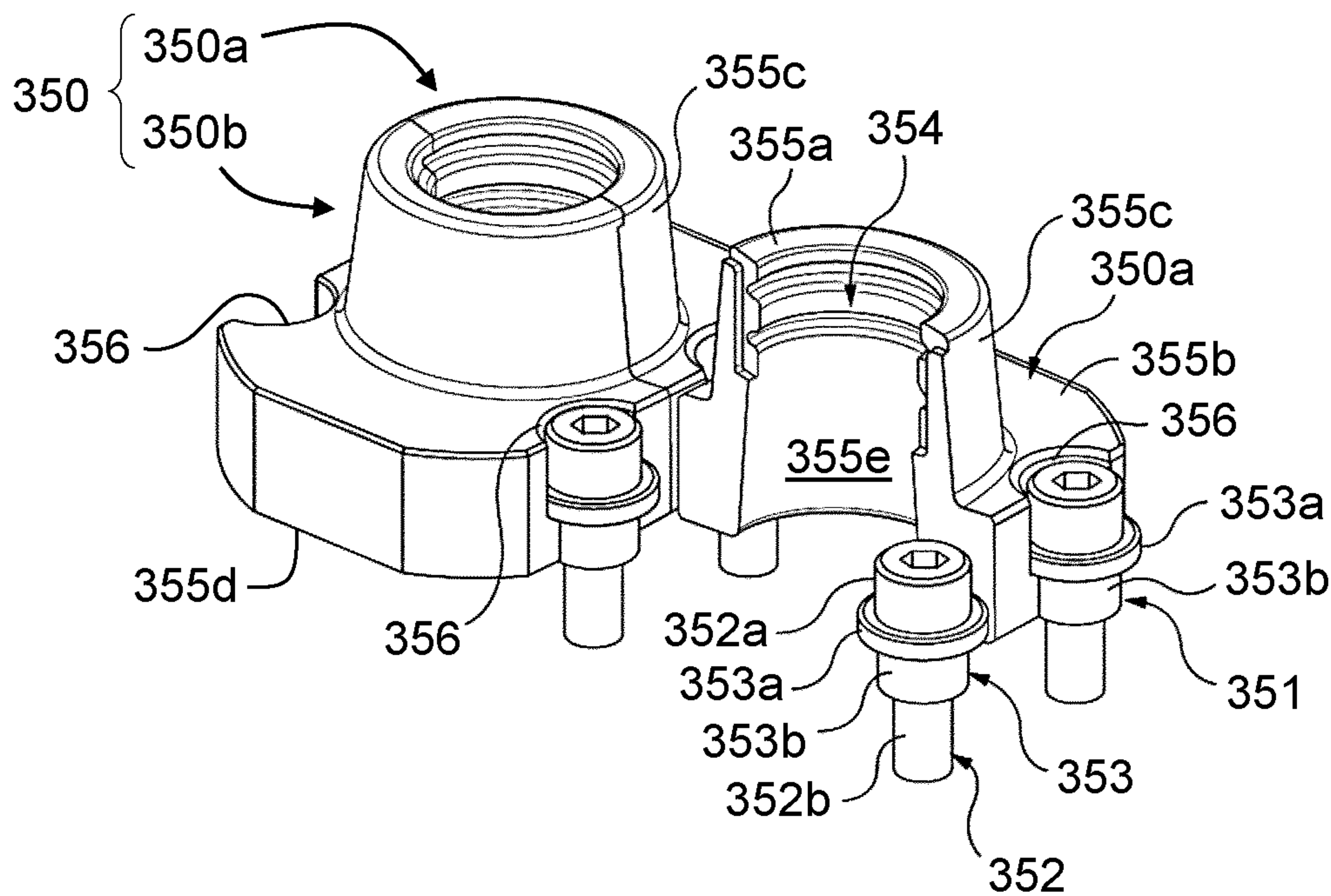


FIG. 24

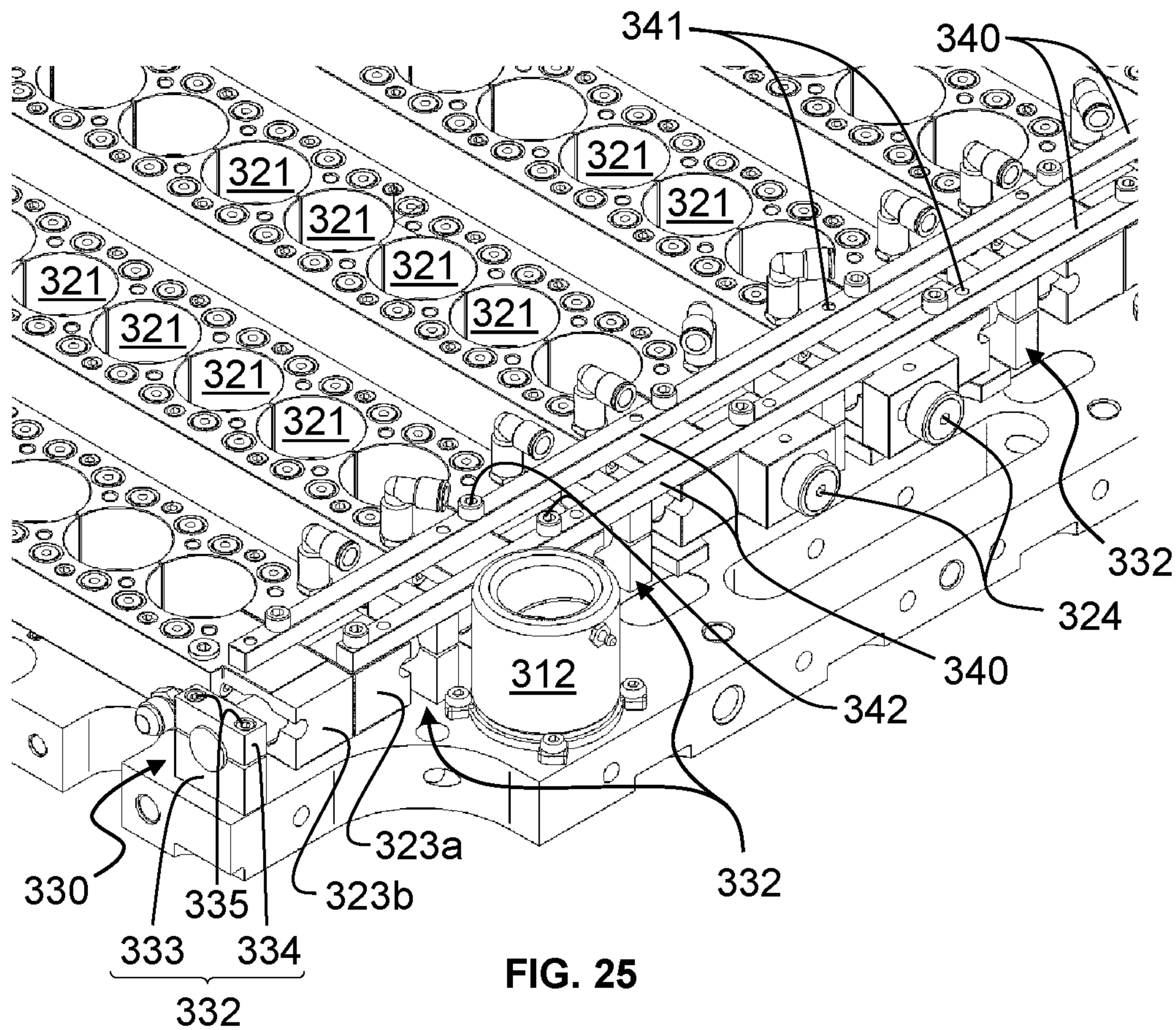


FIG. 25

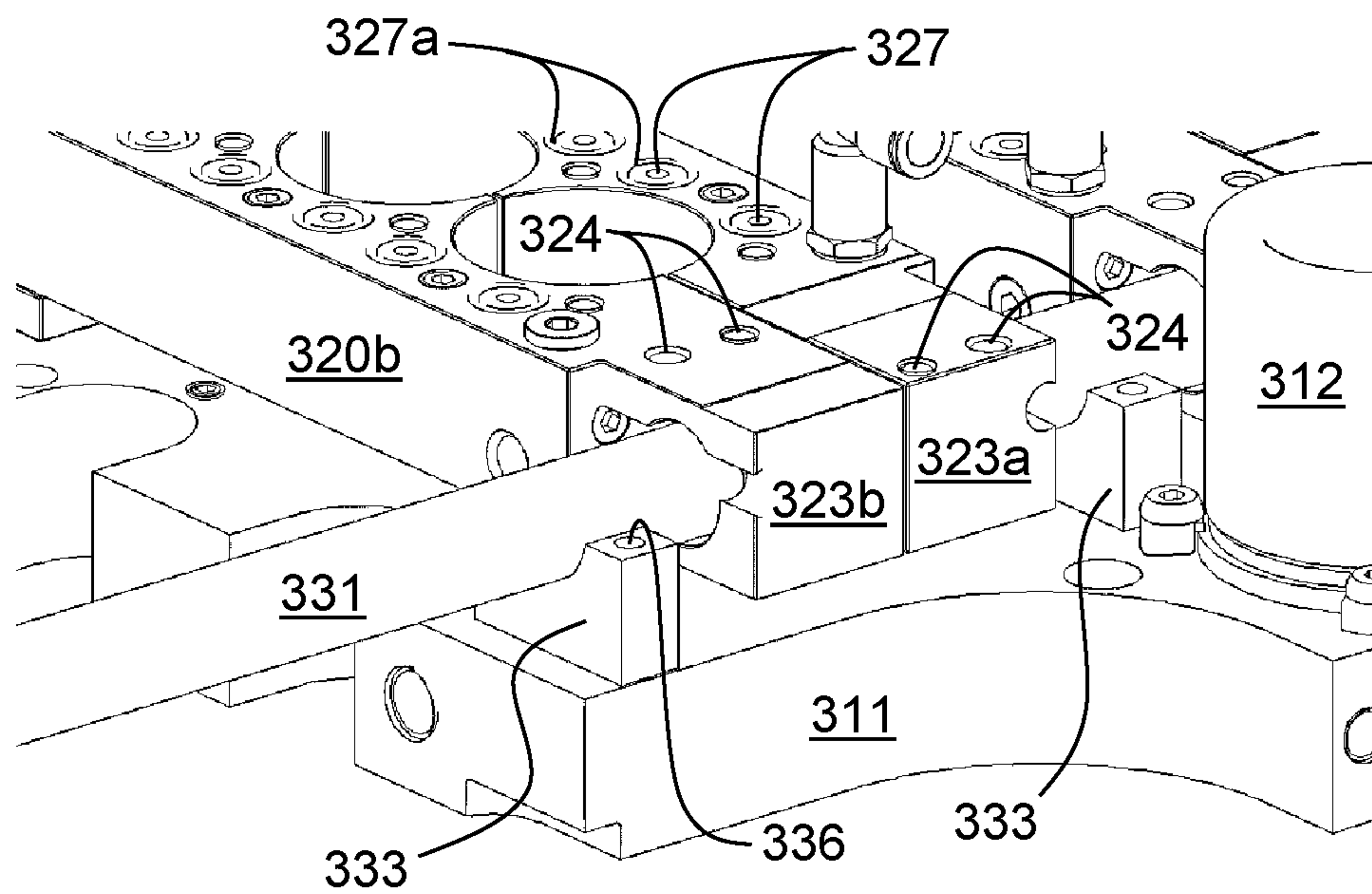


FIG. 26

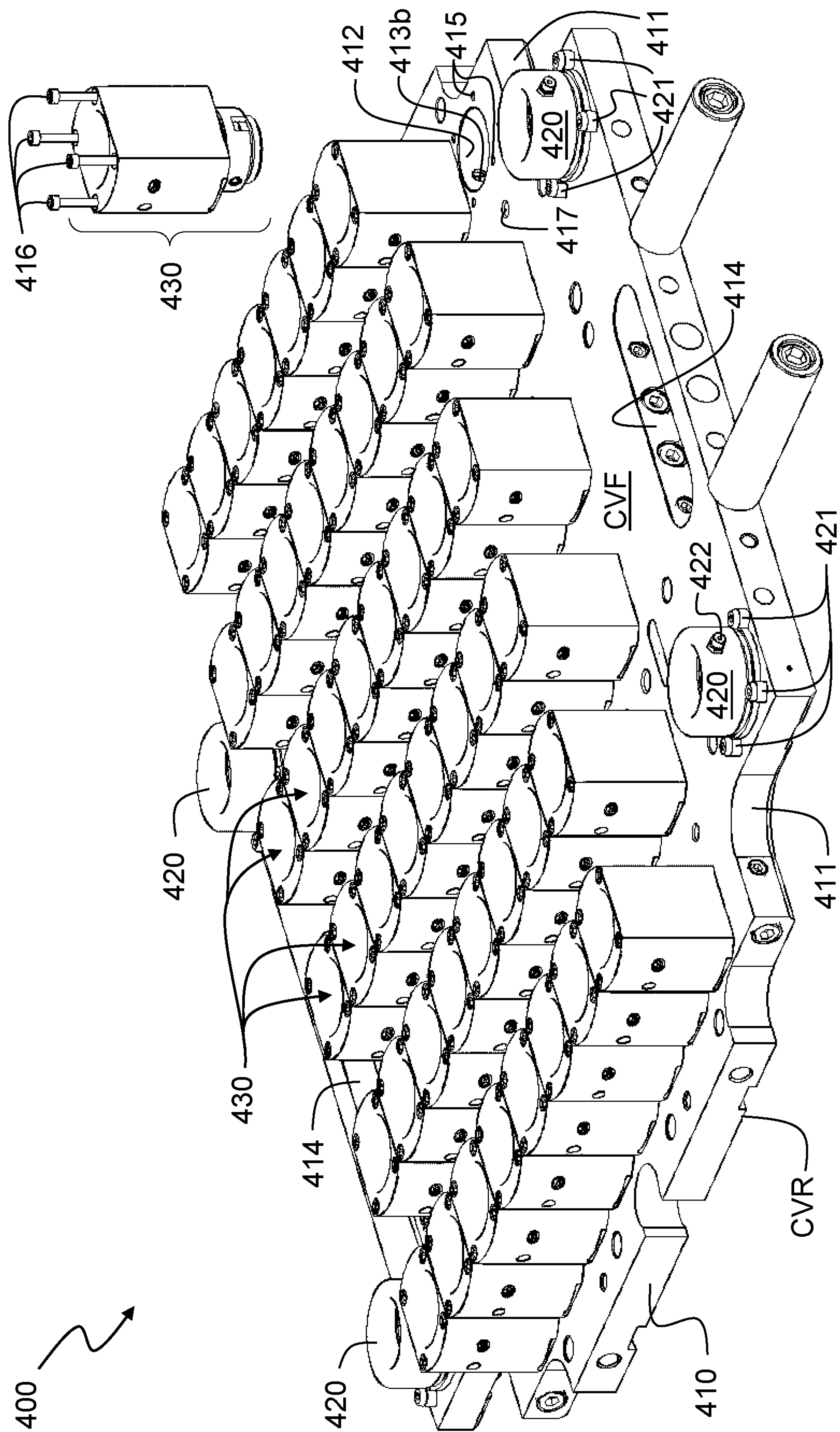


FIG. 27

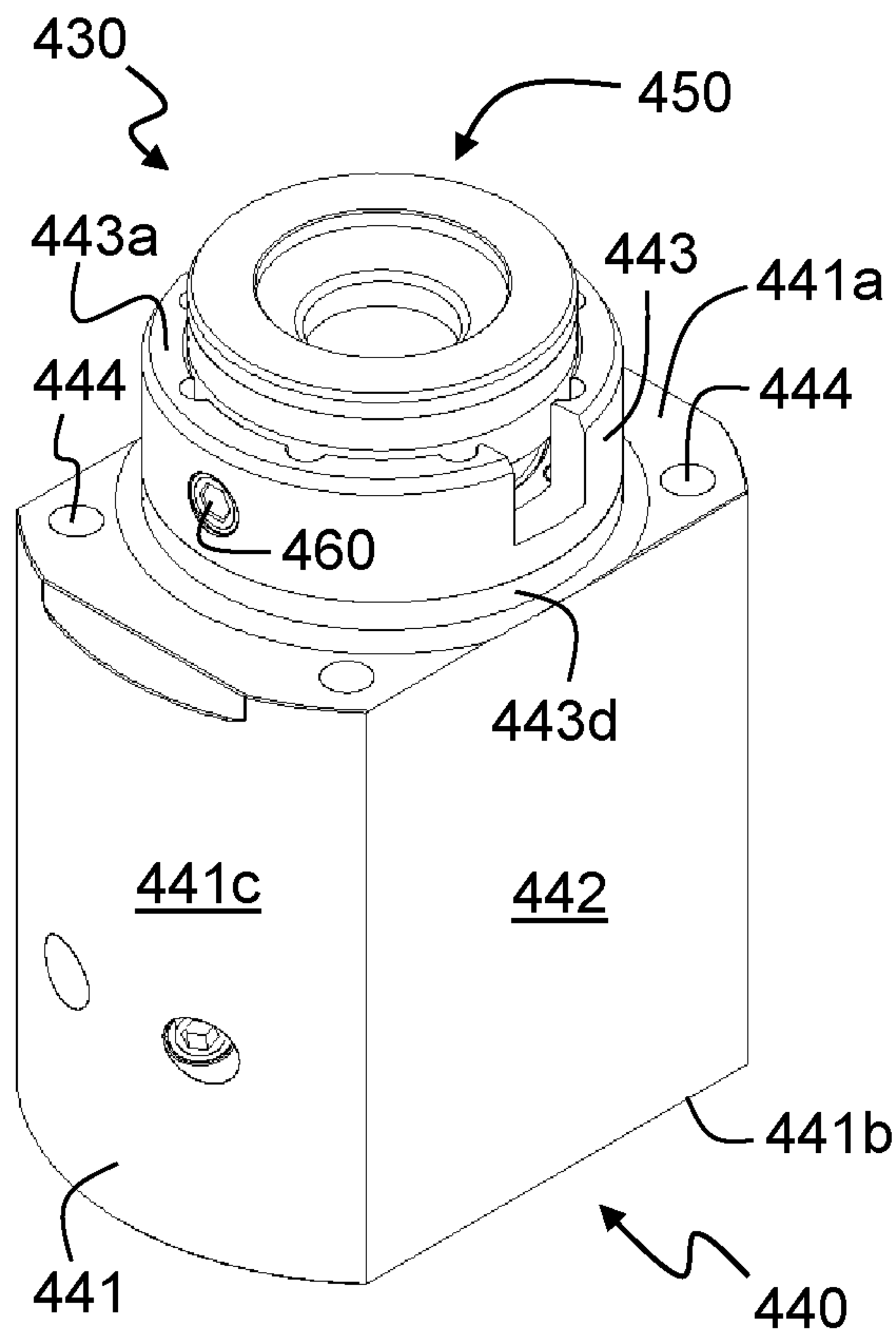


FIG. 28

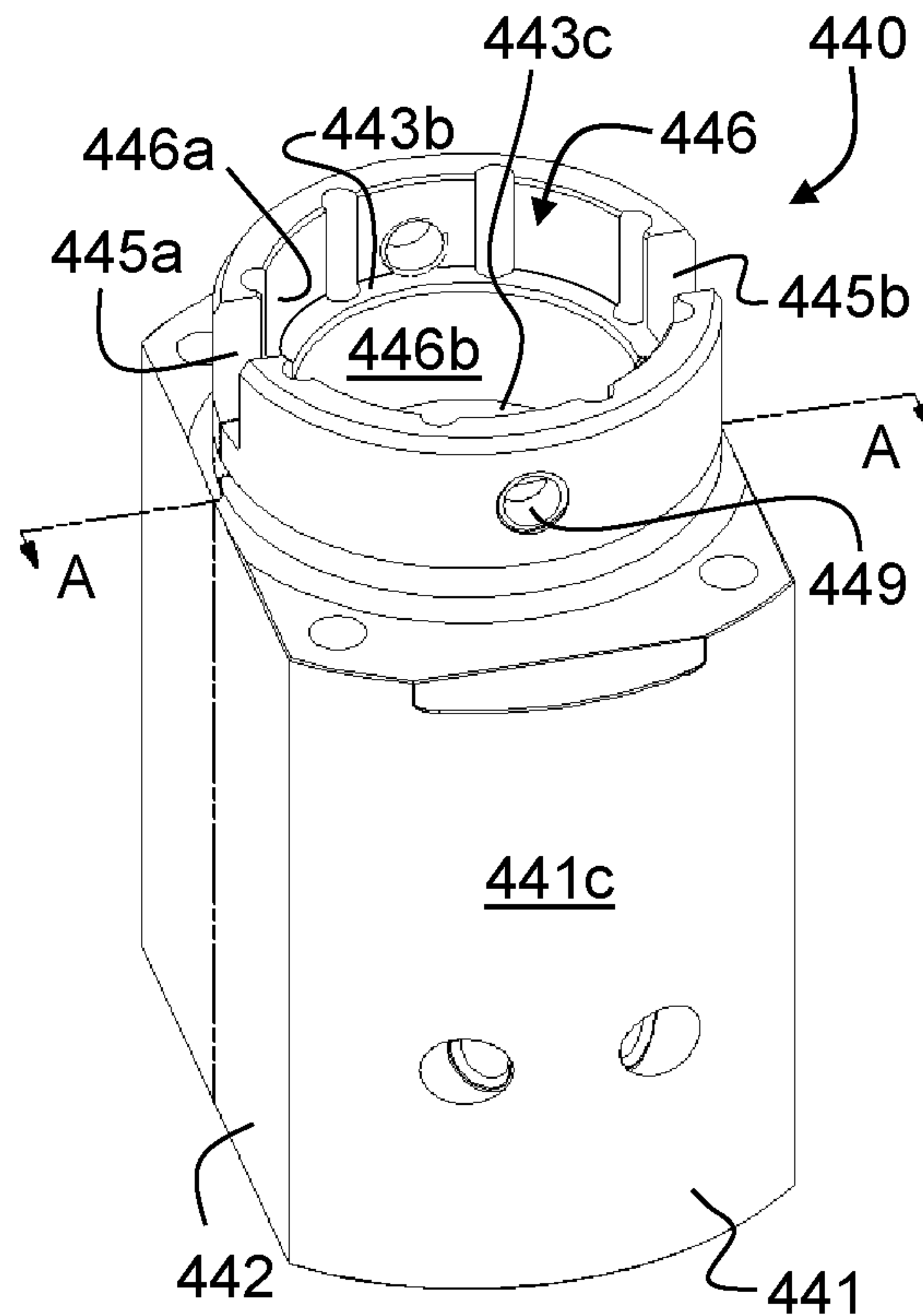


FIG. 29

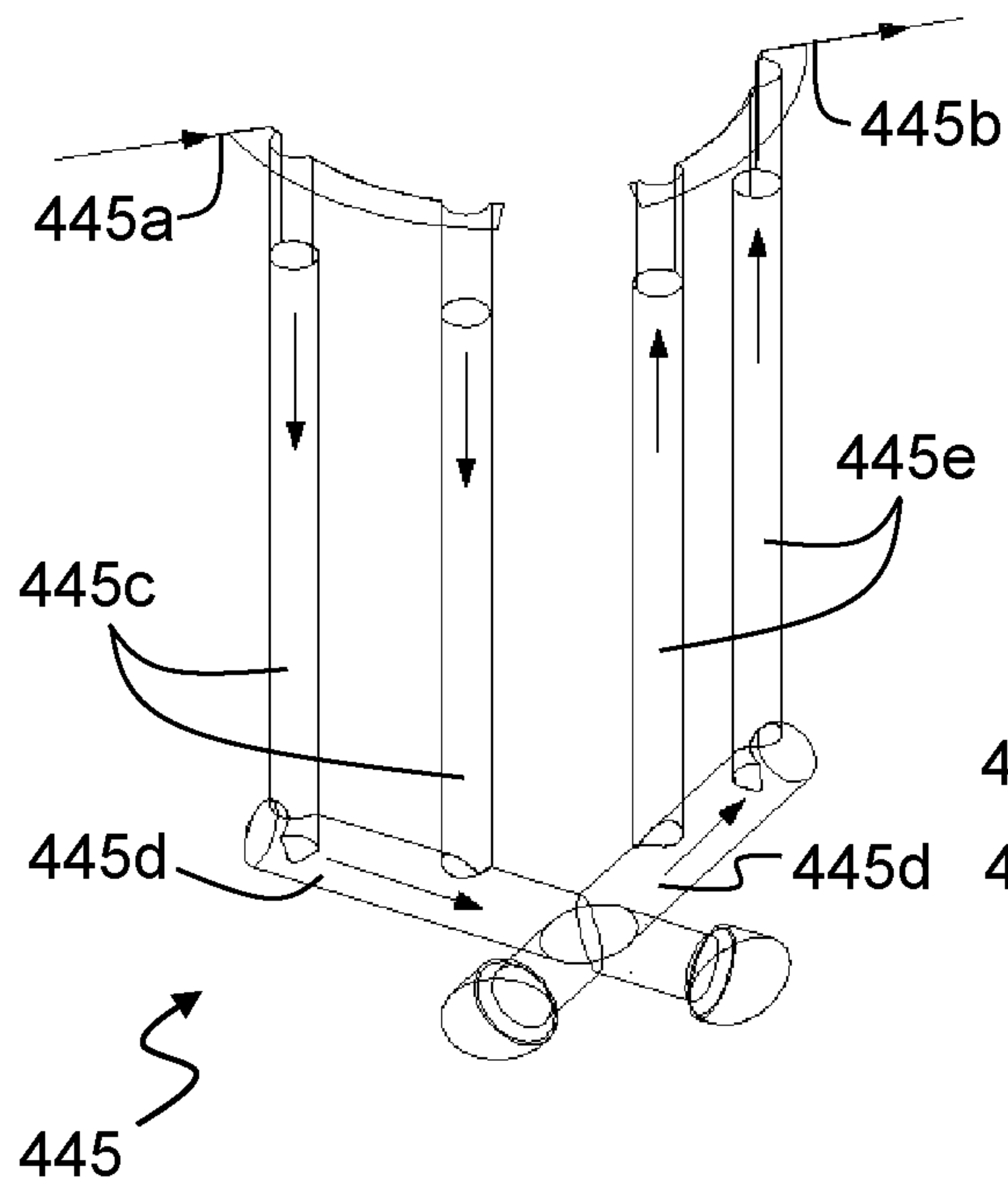


FIG. 30

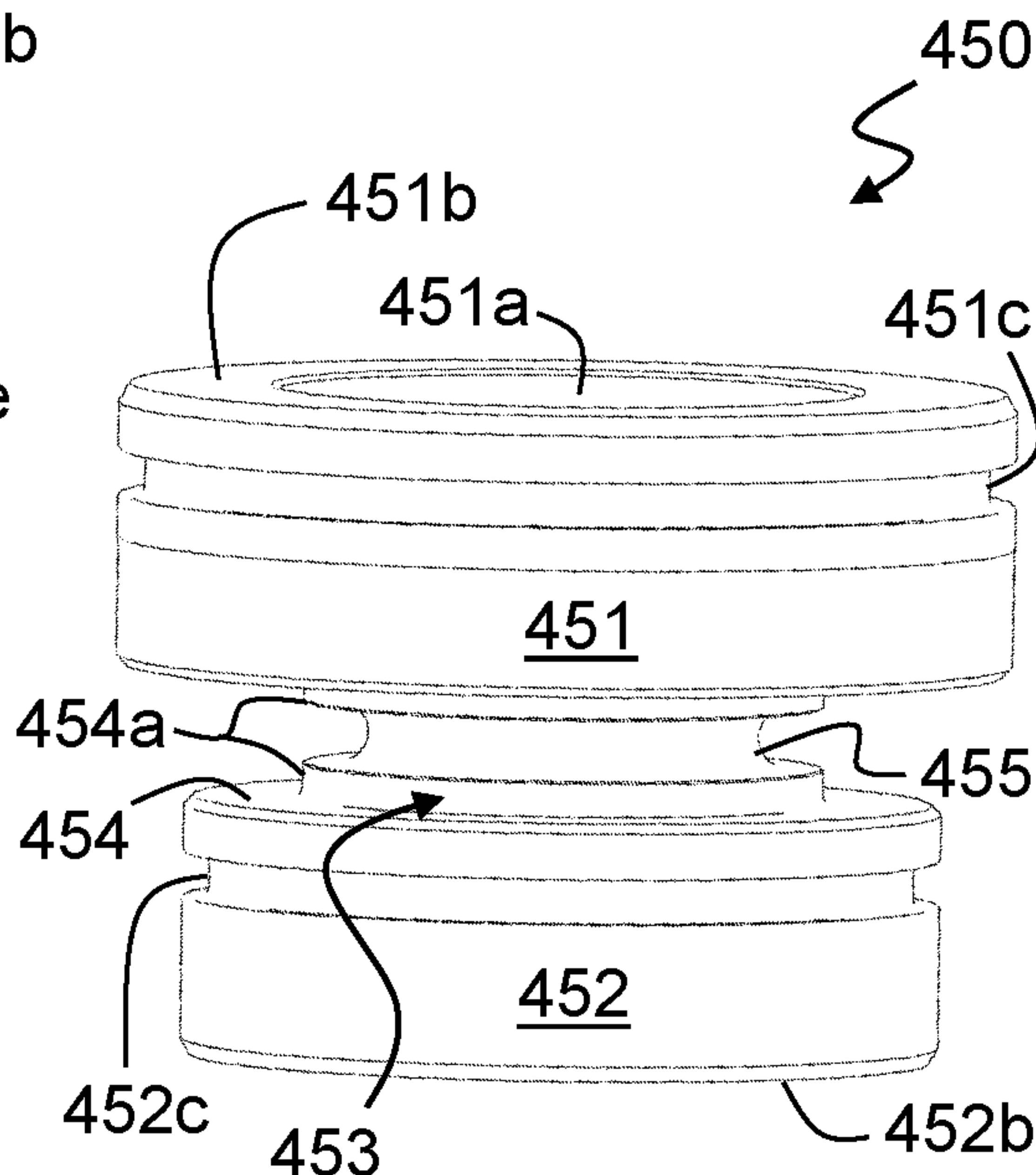


FIG. 31

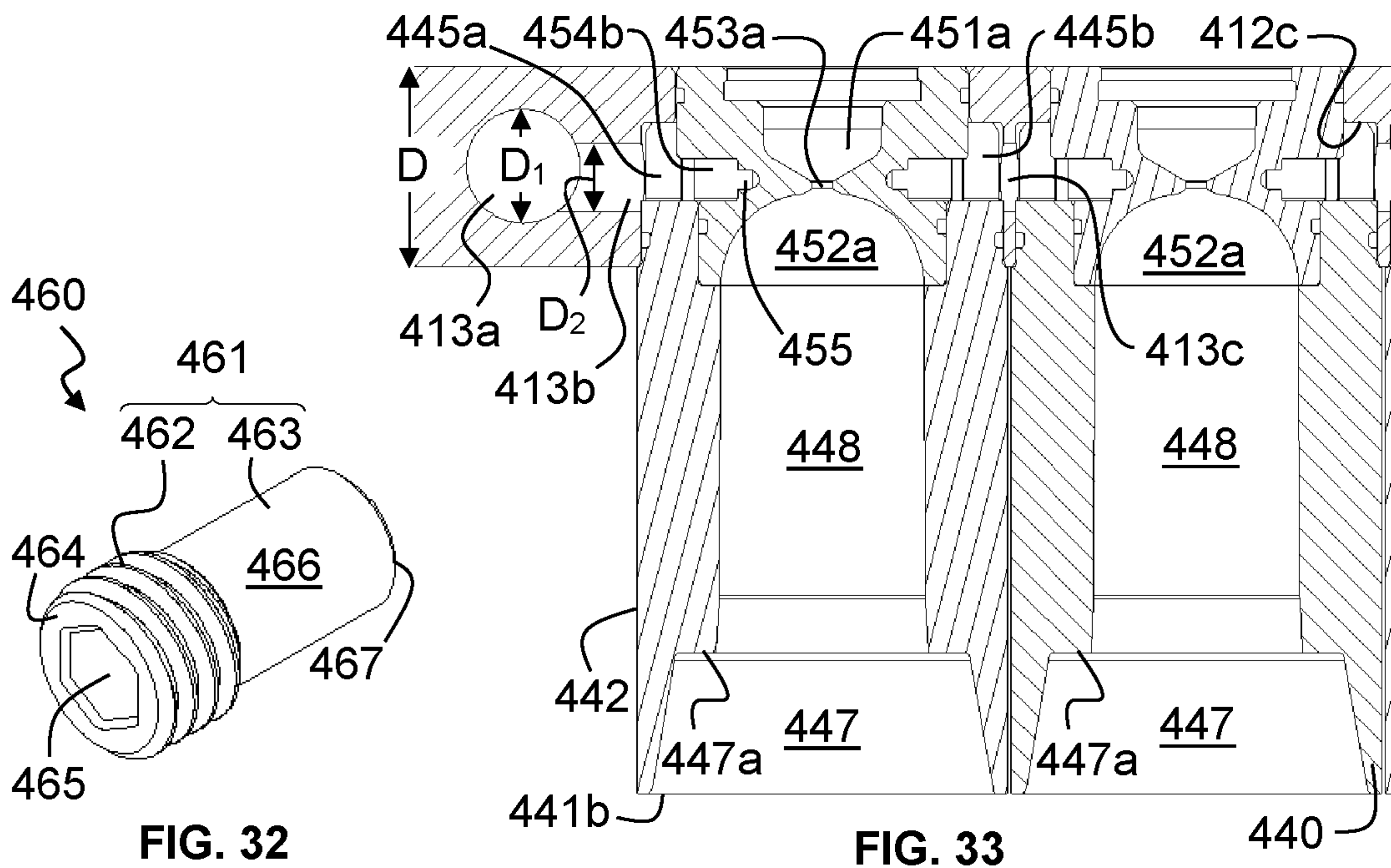


FIG. 32

FIG. 33

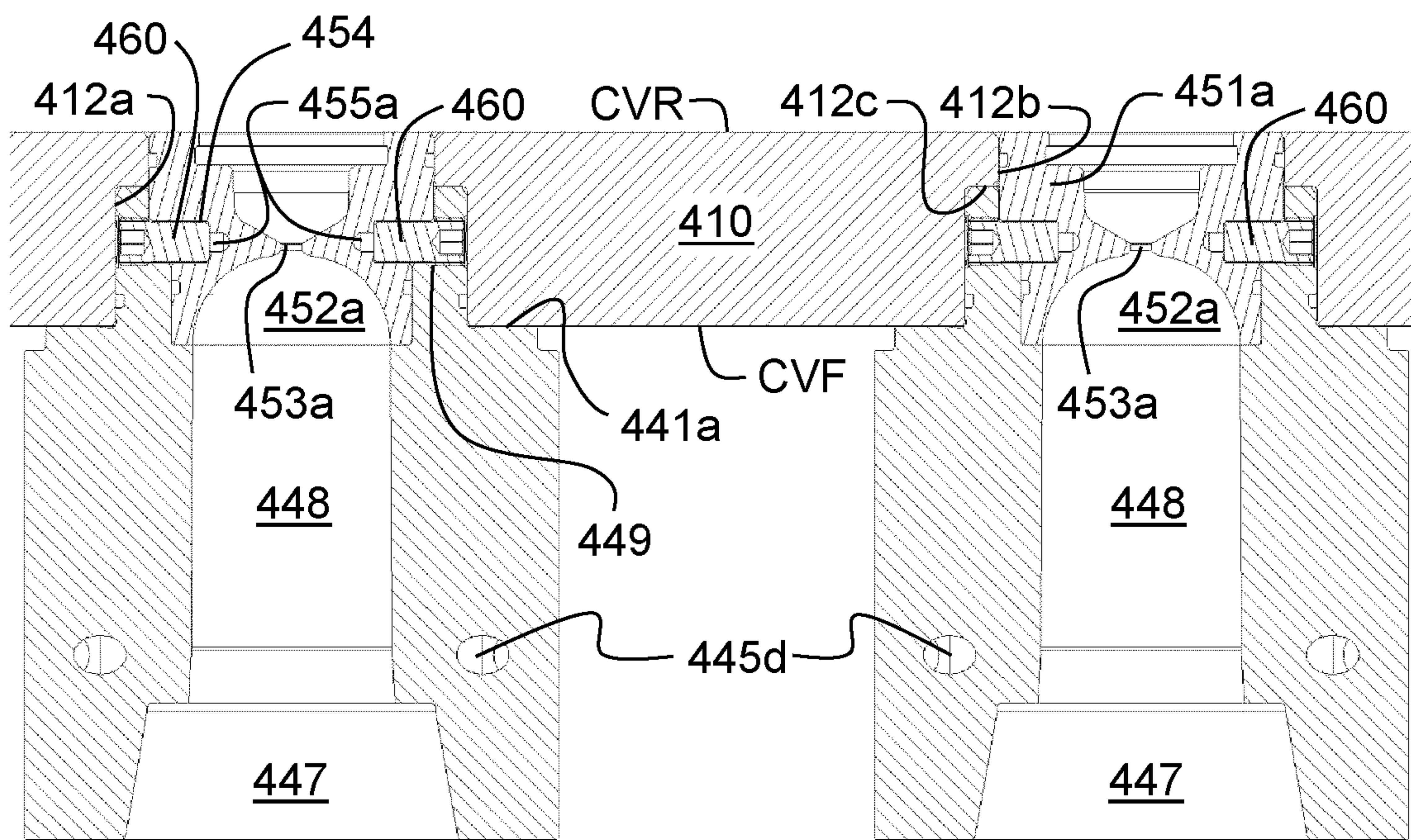
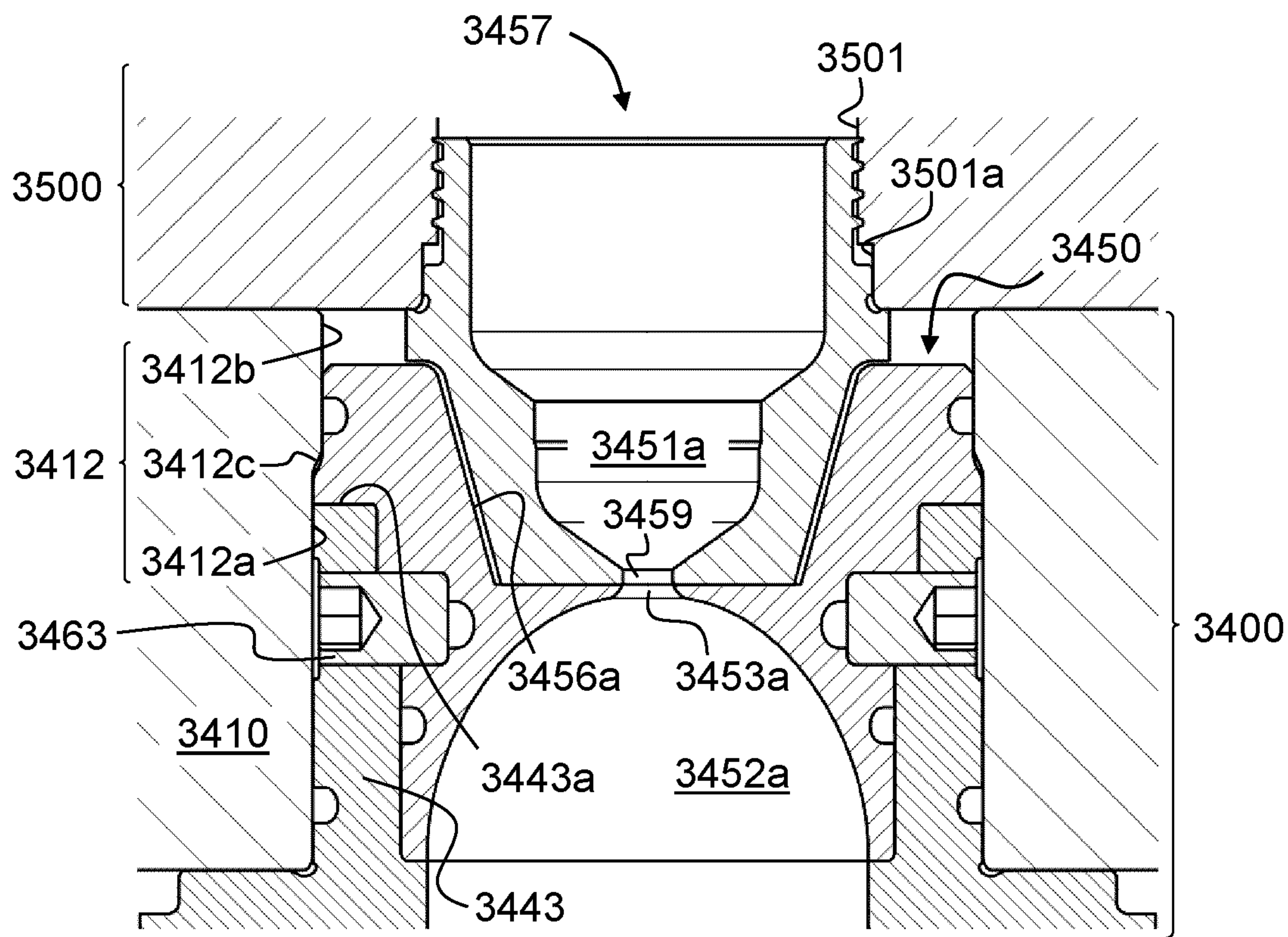
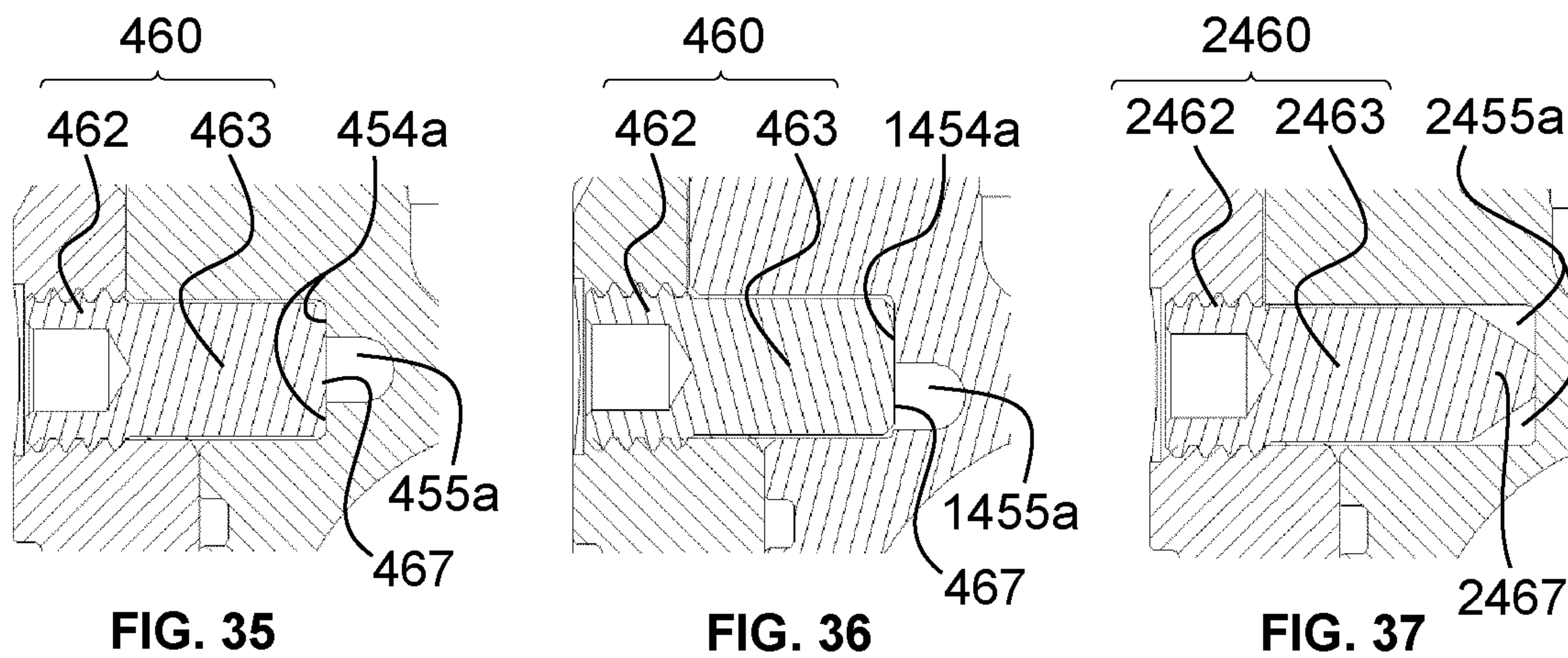
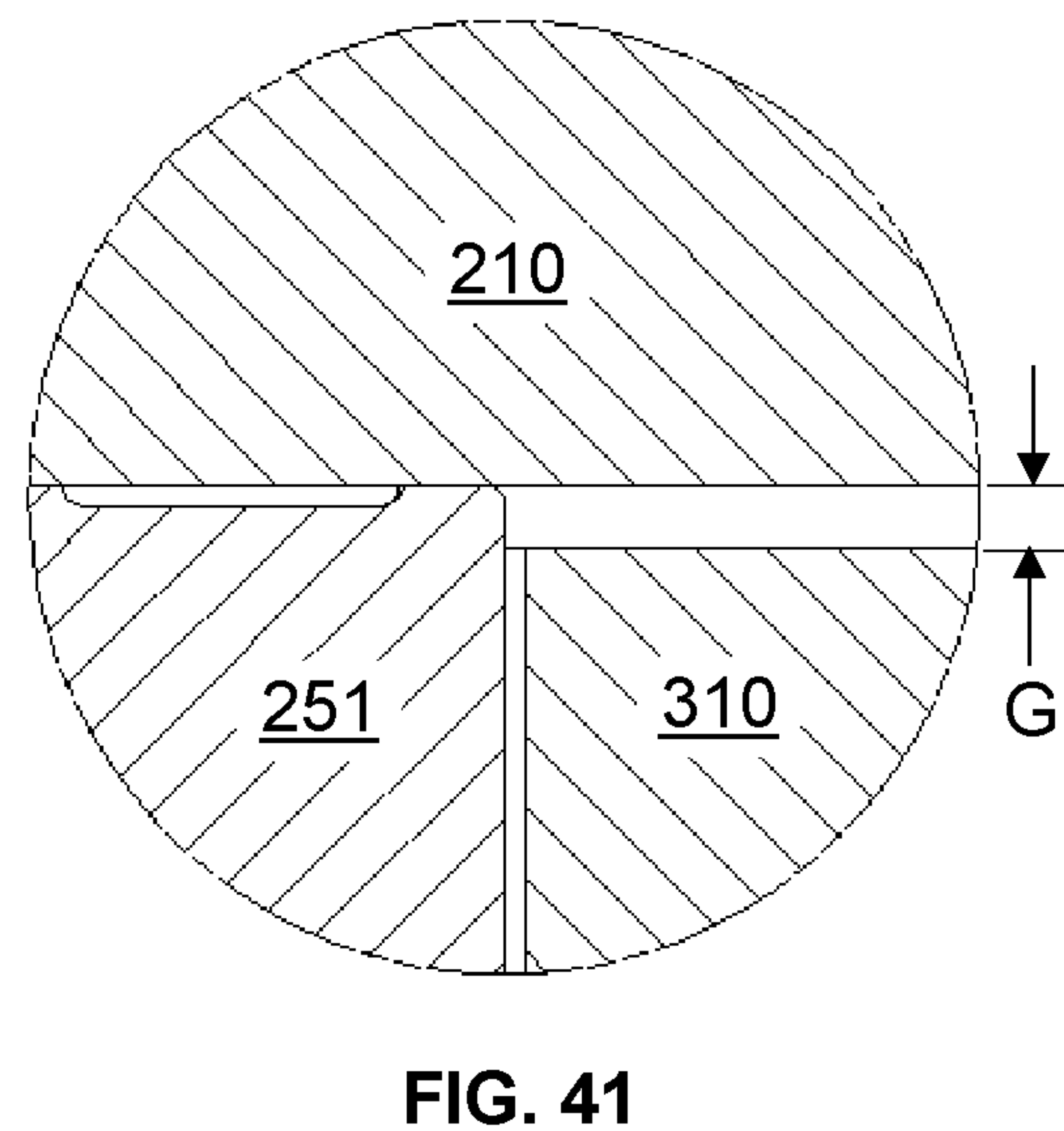
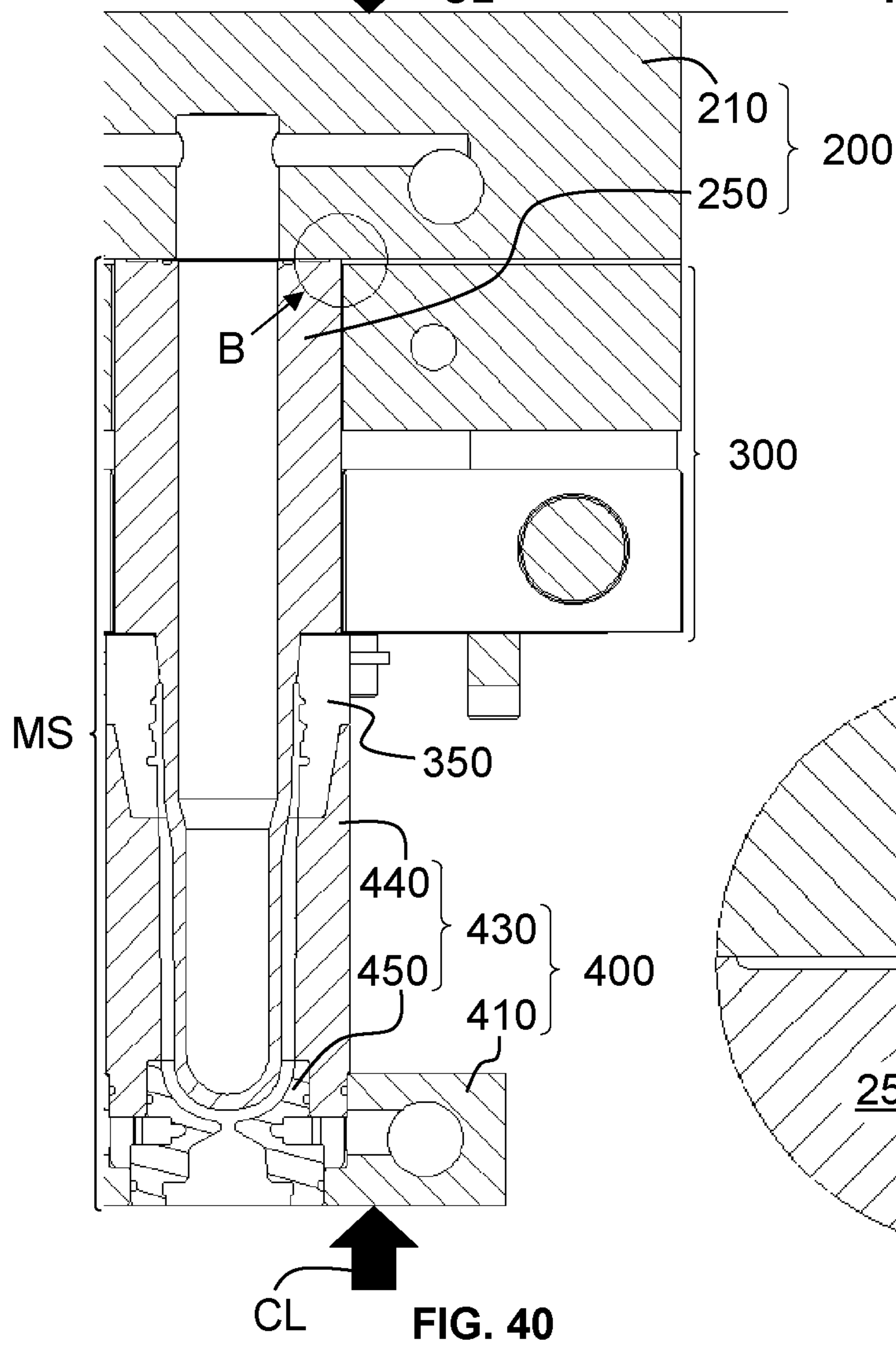
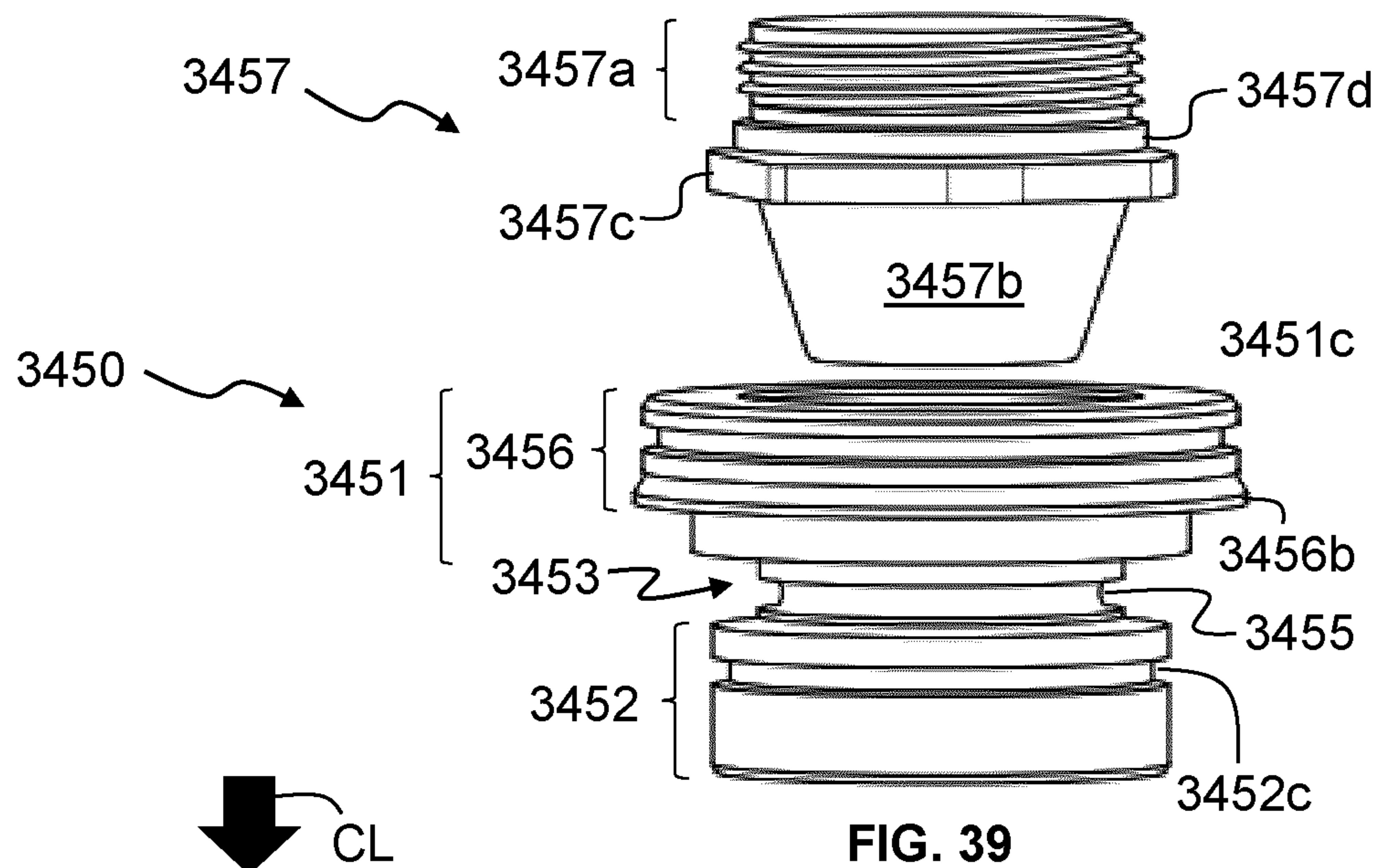


FIG. 34





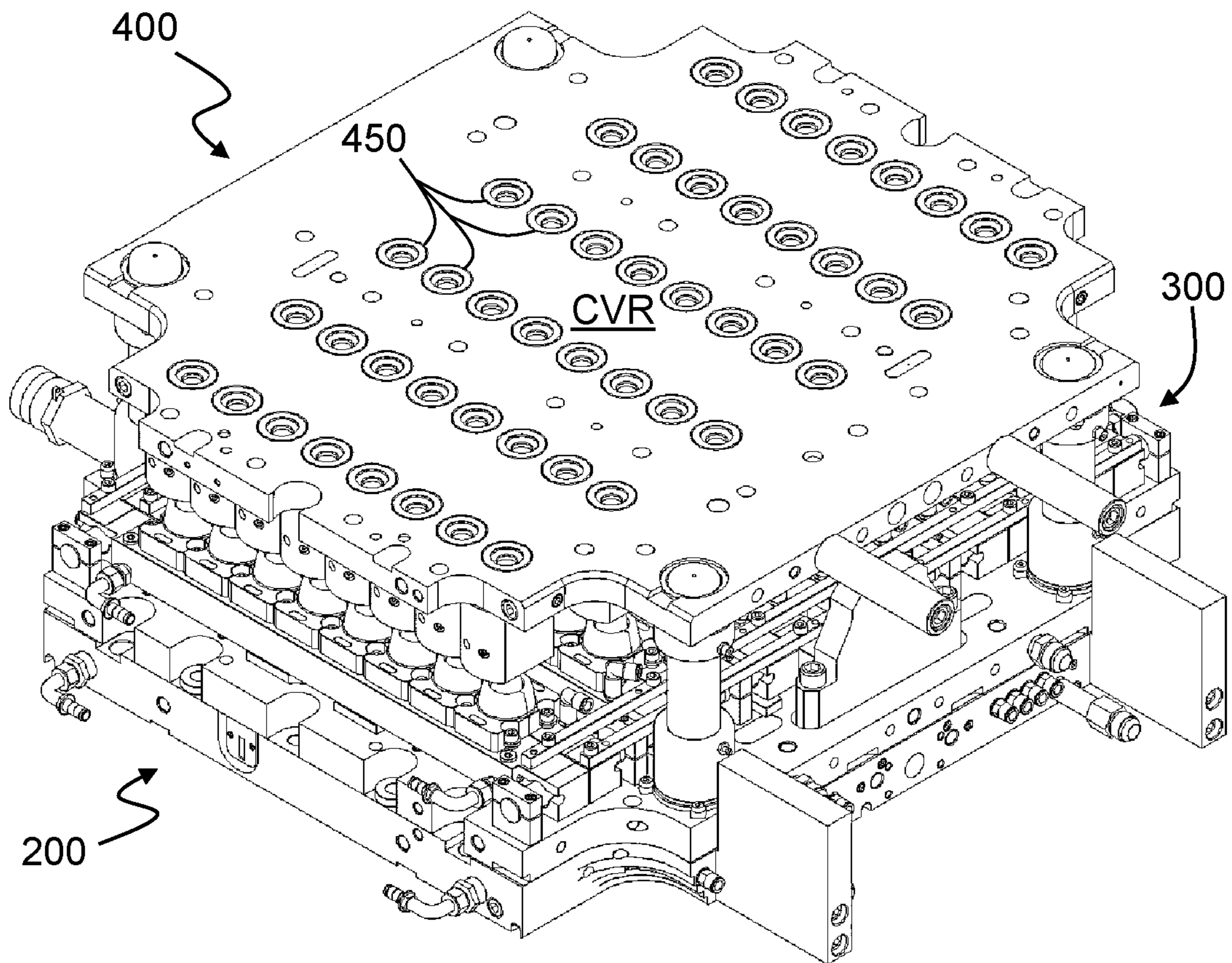


FIG. 42

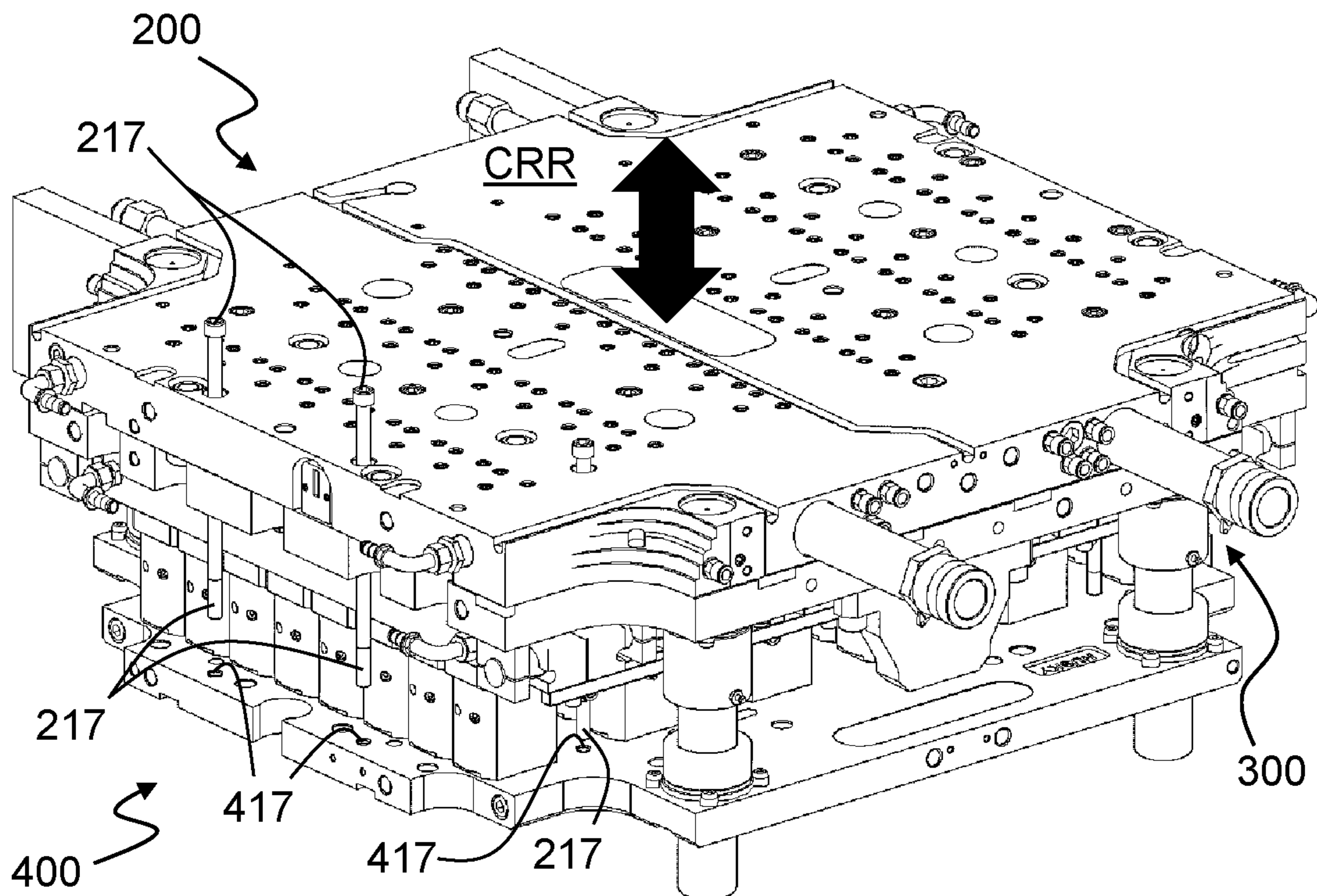


FIG. 43

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MOLDS, MOLD ASSEMBLIES AND STACK COMPONENTS

FIELD OF THE INVENTION

This invention relates generally to molding apparatus and associated methods. More specifically, although not exclusively, this invention relates to mold stacks, mold assemblies, molds, molding systems for molding preforms and other articles, for example tubular articles, and to associated methods.

BACKGROUND OF THE INVENTION

Molding is a process by virtue of which a molded article can be formed from molding material, such as a plastics material, by using a molding system, such as an injection molding system or a compression molding system. Various molded articles can be formed by using such molding processes including, for example, preforms which can be formed from polyethylene terephthalate (PET) material. Such preforms are capable of being subsequently blown into a container, for example a beverage container, bottle, can or the like.

As an illustration, injection molding of preforms involves heating PET material (or other suitable molding material for that matter) to a homogeneous molten state and injecting, under pressure, the so-melted material into a molding cavity defined, at least in part, by a female cavity piece and a male core piece. Typically, the female cavity piece is mounted to a cavity plate and the male core piece is mounted to a core plate of a mold. The cavity plate and the core plate are urged together and are held together by clamp force, the clamp force being sufficient to keep the cavity and the core pieces together against the pressure of the injected material. The molding cavity has a shape that substantially corresponds to a final cold-state shape of the molded article to be molded. The so-injected material is then cooled to a temperature sufficient to enable removal of the so-formed molded article from the molding cavity. When cooled, the molded article shrinks inside of the molding cavity and, as such, when the cavity and core plates are urged apart, the molded article tends to remain associated with the core piece.

Accordingly, by urging the core plate away from the cavity plate, the molded article can be subsequently demolded by ejecting it off the core piece. Ejection structures are known to assist in removing the molded articles from the core halves. Examples of the ejection structures include stripper plates, stripper rings and neck rings, ejector pins, etc.

When dealing with molding a preform that is capable of being subsequently blown into a beverage container, one consideration that needs to be addressed is forming a so-called "neck region". Typically and as an example, the neck region includes (i) engaging features, such as threads (or other suitable structure), for accepting and retaining a closure assembly (ex. a bottle cap), and (ii) an anti-pilferage assembly to cooperate, for example, with the closure assembly to indicate whether the end product (i.e. the beverage container that has been filled with a beverage and shipped to a store) has been tampered with in any way. The neck region may comprise other additional elements used for various purposes, such as to cooperate with parts of the molding system (ex. a support ledge, etc.). As is appreciated in the art, the neck region cannot be formed easily by using the cavity and core halves. Traditionally, split mold inserts (sometimes

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referred to by those skilled in the art as "neck ring") have been used to form the neck region.

A typical molding insert stack assembly that can be arranged (in use) within a molding machine includes a split mold insert pair that, together with a mold cavity insert, a gate insert and a core insert, defines a molding cavity. Molding material can be injected into the molding cavity from a source of molding material via a receptacle or port in the gate insert to form a molded article. In order to facilitate forming of the neck region of the molded article and subsequent removal of the molded article therefrom, the split mold insert pair comprises a pair of complementary split mold inserts that are mounted on adjacent slides of a slide pair. The slide pair is slidably mounted on a top surface of a stripper plate.

As commonly known, the stripper plate is configured to be movable relative to the cavity insert and the core insert, when the mold is arranged in an open configuration. As such, the slide pair, and the complementary split mold inserts mounted thereon, can be driven laterally, via a cam arrangement or any other suitable known means, for the release of the molded article from the molding cavity. One of the functions performed by the split mold insert pair is to assist in ejecting the molded article off the core insert by "sliding" the molded article off the core insert.

SUMMARY OF THE INVENTION

The present invention seeks to provide an alternative mold assembly, preferably one which is more versatile and with greater modularity, for molding articles, specifically but not exclusively tubular articles such as preforms. This invention is directed, in particular but not exclusively, to mold stacks, molds, mold assemblies, molding systems and associated methods. In the case of tubular articles such as preforms, the articles may have a base portion at a closed end, a neck finish at an open end and a body portion therebetween. The neck finish may include one or more radial flanges, which may extend outwardly. The neck finish may include engaging features, such as threads or a snap fit finish. The preform and/or neck finish may comprise any one or more other features described above in relation to known preform designs. In addition, any of the foregoing features described in relation to known mold stacks, molds and molding systems may be incorporated within mold stacks, molds and molding systems according to the invention, insofar as they are consistent with the disclosure herein.

According to a first broad aspect of the present invention, there is provided a mold assembly, e.g. a cavity plate assembly, for a mold, e.g. a preform mold, the assembly comprising a cavity plate having one or more seats and one or more cavity inserts mounted to a front face of the cavity plate and in communication with a respective seat, wherein the or each cavity insert comprises a molding cavity or molding surface along its length at least two thirds of which extends beyond the cavity plate.

The cavity insert may comprise a taper at a first end and/or a mounting face at or adjacent a second end, e.g. for mounting the cavity insert to a cavity plate. At least two thirds of the molding cavity or molding surface may be between the taper and the mounting face.

Another aspect of the invention provides a cavity insert, e.g. a preform cavity insert, comprising a taper at a first end, a molding cavity or molding surface along its length, a mounting face at or adjacent a second end for mounting the

cavity insert to a cavity plate, wherein at least two thirds of the molding cavity or molding surface is between the taper and the mounting face.

At least 70% or 75% or 80% or 85% or 90% of the molding cavity or molding surface may extend beyond the cavity plate. At least 70% or 75% or 80% or 85% or 90% of the molding cavity or molding surface may be between the taper and the mounting face.

The cavity plate may comprise a rear face, e.g. for mounting to a melt distributor. The cavity plate may comprise a depth described from the front face to the rear face. The cavity plate may comprise a cooling channel, which may be described therein. The cooling channel may have a depth that is at least 15% of the plate depth.

Another aspect of the invention provides a mold assembly, e.g. a cavity plate assembly, for a mold, e.g. a preform mold, the assembly comprising a cavity plate having one or more seats and one or more cavity inserts mounted to a front face of the cavity plate and in communication with a respective seat, wherein the cavity plate comprises a rear face for mounting to a melt distributor, a depth described from the front face to the rear face and a cooling channel described therein which has a depth that is at least 15% of the plate depth.

Another aspect of the invention provides a cavity plate, e.g. a preform cavity plate, comprising a cooling channel described therein, a front face with an array of seats in fluid communication with the cooling channel for connection with respective cavity inserts, a rear face for mounting to a melt distributor and a depth described from the front face to the rear face, wherein the cooling channel has a depth that is at least 15% of the plate depth.

The cooling channel depth may be at least 20% or 25% or 30% or 40% or 45% or 50% of the plate depth.

The or each cavity insert may comprise a body, which may include the mounting face, e.g. at or adjacent one of its ends. The or each cavity insert may comprise a spigot, which may project from the mounting face. The spigot may be received or receivable in a respective seat of the cavity plate, e.g. such that the mounting face abuts the front face of the cavity plate. The spigot may comprise a cooling channel inlet and/or a cooling channel outlet. The cooling channel inlet and/or the cooling channel outlet may be in fluid communication with, or suitable or configured for fluid connection with, a cooling channel opening in the seat of the cavity plate.

Another aspect of the invention provides a mold assembly, e.g. a cavity plate assembly, for a mold, e.g. a preform mold, the assembly comprising a cavity plate having one or more seats and one or more cavity inserts mounted to a front face of the cavity plate and in communication with a respective seat, wherein the or each cavity insert comprises a body with a mounting face and a spigot projecting from the mounting face and received in a respective seat of the cavity plate such that the mounting face abuts the front face of the cavity plate, each spigot preferably comprising a cooling channel inlet and a cooling channel outlet both of which are in fluid communication with respective cooling channel openings in the seat of the cavity plate.

Another aspect of the invention provides a cavity insert, e.g. a preform cavity insert, comprising a molding cavity or molding surface along its length, a body with a mounting face at or adjacent one of its ends for mounting the cavity insert to a cavity plate and a spigot projecting from the mounting face for receipt within a seat of a cavity plate, wherein the spigot preferably comprises a cooling channel

inlet and a cooling channel outlet for fluid connection with respective cooling channel openings in the seat of the cavity plate.

The cooling channel openings in each seat may be located at substantially the same depth. The cooling channel openings in each seat may be on opposite sides thereof. The cooling channel inlet may be on a first side of the spigot and/or of the cavity insert. The cooling channel outlet may be on a second side of the spigot and/or of the cavity insert, which may be opposite the first side.

The cavity insert may comprise one or more cooling channels, which may extend along or parallel and/or adjacent the molding cavity or molding surface. The one or more cooling channels may comprise one or more axial channels, which may extend along or parallel and/or adjacent the molding cavity or molding surface. The one or more cooling channels may comprise one or more transverse channels, which may extend about or around and/or adjacent the molding cavity or molding surface. The axial channel(s) may comprise a plurality of axial channels, which may be connected together by the transverse channel(s). The transverse channel(s) may extend tangentially with respect to the molding cavity or molding surface and/or may be spaced therefrom. The transverse channel(s) may intersect some or all of the axial channels, for example to fluidly connect them.

The cavity insert may comprise a first cooling circuit, which may be in fluid communication with the cooling channel inlet and/or may extend along the first side of the cavity insert. The first cooling circuit may comprise one or more, e.g. a plurality of, the axial channels. The cavity insert may comprise a second cooling channel circuit, which may be in fluid communication with the cooling channel outlet and/or may extend along the second side of the cavity insert. The first cooling circuit may comprise one or more, e.g. a plurality of, the axial channels.

The mounting face may be at or adjacent a first end of the body and the body may comprise a second end. The first cooling circuit may be fluidly connected to the second cooling circuit at the second end of the body, e.g. such that cooling fluid entering, in use, into the cooling channel inlet flows through the first cooling circuit toward the second end, into and through the second cooling circuit back toward the first end and out of the cooling channel outlet.

The body may be substantially cylindrical, for example with a pair of flat sides, e.g. for reducing the minimum pitch between adjacent cavity inserts. The molding cavity or molding surface may be substantially cylindrical. The spigot may be substantially cylindrical. The spigot may comprise a gate insert seat, e.g. for receiving a gate insert.

The assembly may comprise a gate insert, which may be received within the or a seat in the spigot of at least one or each cavity insert.

Another aspect of the invention provides a cavity assembly comprising a cavity insert, e.g. as described above, and a gate insert received within the gate insert seat.

The or each gate insert may comprise a cooling channel, which may be in fluid communication with the cooling channel inlet of the spigot, e.g. for receiving cooling fluid therefrom. The cooling channel may be in fluid communication with the cooling channel outlet of the spigot, e.g. for supplying cooling fluid thereto. The assembly may comprise a diverter, e.g. for diverting, in use, cooling fluid from the cooling channel of the gate insert and/or into one or more cooling channels of the cavity insert. The diverter may separate the cooling channel of the gate insert into two segments.

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A first of the cooling channel segments may provide a fluid connection between the cooling channel inlet of the spigot and one or more cooling channels, e.g. axial cooling channels, of the cavity insert. The first cooling channel segment may provide a fluid connection between the cooling channel inlet of the spigot and the first cooling circuit of the cavity insert. A second of the cooling channel segments may provide a fluid connection between the cooling channel outlet of the spigot and the cooling channels, e.g. axial cooling channels, of the cavity insert. The second cooling channel segment may provide a fluid connection between the cooling channel outlet of the spigot and the second cooling circuit of the cavity insert.

The cooling channel of the gate insert may comprise a circumferential cooling groove, which may cooperate with a facing surface of the gate insert seat of the spigot. The diverter may comprise a projection or pin, which may extend from the spigot into the cooling groove. The diverter a pair of opposed pins, which may be received within the cooling groove, e.g. to the first and second cooling channel segments.

The assembly may comprise a bypass channel, which may be described between the pins and the gate insert. The bypass channel may allow restricted flow from the first cooling channel segment to, e.g. directly to, the second cooling channel segment. The bypass channel may be provided by a circumferential recess, which may be in the circumferential cooling groove of the gate insert. The circumferential cooling groove of the gate insert may comprise a primary groove. The bypass channel may be provided at least in part by a secondary groove, which may be in the base of the primary groove. Additionally or alternatively, the bypass channel may be provided by a hole or cutaway in one or both of the projections or pins.

The or each projection or pin may be threadedly engaged in a hole through the spigot of the cavity insert. The or each projection or pin may serve as a retaining means or pin, e.g. for retaining the cavity insert within the seat of the spigot. At least part of the pin may comprise an external thread. At least part of the pin may comprise a featureless and/or smooth circumferential surface. In some examples, part of the pin has an external thread and part of the pin has a featureless and/or smooth circumferential surface.

The cavity insert may comprise a pair of threaded holes, which may be through the spigot, e.g. for threadedly receiving retaining pins extending into the gate insert seat. The threaded holes and/or the cooling channel inlet and outlet may be spaced equally about the periphery of the spigot. The threaded holes may be between the cooling channel inlet and outlet and/or may extend orthogonally or perpendicular with respect thereto.

The or each seat may comprise a first seat portion, which may extend from the front face, and/or a second seat portion, which may extend from the rear face. The first seat portion may be larger or smaller than the second seat portion, e.g. with a shoulder or transition described therebetween. The spigot of the cavity insert may be received in the first seat portion and/or may abut the shoulder or transition. Alternatively, the gate insert may abut the shoulder or transition. The front face may comprise a mounting interface, e.g. adjacent each seat, to which a cavity insert is mounted, in use, such that a spigot thereof is received within the first seat portion and/or abuts against the shoulder.

Another aspect of the invention provides a cavity plate, e.g. a preform cavity plate, comprising a front face, a rear face and an array of seats with cooling channel openings therein, each seat comprising a first seat portion extending

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from the front face and a second seat portion extending from the rear face, the first seat portion being larger than the second seat portion with a shoulder or transition described therebetween, wherein the front face comprises a mounting interface adjacent each seat to which a cavity insert is mounted, in use, such that a spigot thereof is received within the first seat portion, e.g. and abuts against the shoulder.

The or each gate insert may extend from the spigot and/or into the or a respective second seat portion. The or each gate insert may include a seat or recess, e.g. for receiving a gate pad or nozzle tip of a melt distributor. The recess may comprise a gate pad recess, e.g. for receiving an outlet end of a gate pad mounted to a melt distributor. The gate pad recess may be tapered. The gate pad recess may be conical or frustoconical, for example with a flat base. Alternatively, the recess may comprise a nozzle tip seat, e.g. for receiving a nozzle tip of a melt distributor.

Another aspect of the invention provides a preform mold assembly comprising a melt distributor and a cavity plate assembly, e.g. as described above, wherein the melt distributor comprises one or more gate pads mounted thereto each having an outlet end received in a corresponding gate pad recess of the cavity plate assembly.

The gate insert may comprise a body, which may be substantially cylindrical. The gate insert or body may describe the seat or recess, e.g. in a first end of the body. The gate insert may comprise a molding cavity portion, e.g. in a second end of the body. The gate insert may comprise a gate, which may join the seat or recess to the molding cavity portion. The gate may be central and/or may extend from the flat base of the gate pad recess. The gate insert may comprise a cooling groove around the gate and a bypass groove recessed therein. The cooling groove may describe a cooling channel within which is received, in use, a pair of diverters that separate the channel into inlet and outlet channel segments and/or which describe, with the bypass groove, bypass channel segments that allow restricted flow between the inlet and outlet channel segment.

Another aspect of the invention provides a gate insert, e.g. a preform gate insert, comprising a cylindrical body that describes: a gate pad or nozzle seat in a first end of the cylindrical body; a molding cavity portion in a second end of the cylindrical body; a gate joining the gate pad or nozzle seat to the molding cavity portion; and a cooling groove around the gate and having a bypass groove recessed therein; wherein the cooling groove describes a cooling channel within which is received, in use, a pair of diverters that separate the channel into inlet and outlet channel segments and which describe, with the bypass groove, bypass channel segments that allow restricted flow between the inlet and outlet channel segment.

The cylindrical body may comprise a first diameter, which may surround at least part of the gate pad or nozzle seat. The body may comprise a second diameter, which may surround at least part of the molding cavity portion. The second diameter may be smaller than the first diameter. The cooling groove may be located at or adjacent the transition between the first diameter and the second diameter, e.g. thereby providing a necked intermediate portion.

The first end may comprise the first diameter and the second end may comprise the second diameter. Alternatively, the first end may comprise a third diameter, which may be larger than the first diameter, e.g. with a shoulder described therebetween against which the spigot of the cavity insert may abut. The first diameter may be between the second and third diameters.

Another aspect of the invention provides a gate insert, e.g. a preform gate insert, comprising a cylindrical body that describes: a recess or seat, e.g. a gate pad or nozzle seat, in a first end of the cylindrical body, e.g. for receiving a gate pad or nozzle tip; a molding cavity portion in a second end of the cylindrical body; and a gate joining the gate pad or nozzle seat to the molding cavity portion; wherein the recess or seat in the first end is tapered at an included angle of between 10 and 60 degrees, for example between 20 and 50 degrees, 25 and 45 degrees or between 30 and 40 degrees.

Another aspect of the invention provides a preform gate insert, e.g. as described above, in combination with a gate pad, the gate pad comprising a substantially cylindrical body describing a nozzle seat and having a first, threaded end, a second, outlet end for receipt in the gate pad or nozzle seat and a flange between the first and second ends. The flange may comprise one or more flats, e.g. for engaging an installation tool. The flange may comprise a polygonal, e.g. a hexagonal, shape in plan or cross-section.

The outlet end of the gate pad may be tapered. The outlet end of the gate pad may be conical or substantially frusto-conical. The outlet end may be tapered at an included angle of between 10 and 60 degrees, for example between 20 and 50, preferably between 25 and 45 degrees and most preferably between 30 and 40 degrees.

The body may be hollow. The body may comprise a shoulder, which may be between the flange and the first end. The flange and/or the shoulder may protrude outwardly. The nozzle seat may extend from the first end and/or terminate in the second end of the gate pad, e.g. at a gate. The gate may be central and/or cylindrical and/or may form an aperture through a tip of the outlet end.

Another aspect of the invention provides a gate pad comprising a substantially cylindrical body describing a nozzle seat and having a first, threaded end, a second, outlet end for receipt in a seat, e.g. a gate pad or nozzle seat, or recess of a gate insert, wherein the second, outlet end is tapered at an included angle of between 10 and 60 degrees, for example between 20 and 50 degrees, 25 and 45 degrees or between 30 and 40 degrees.

The mold assembly may comprise a melt distributor. The melt distributor may comprise one or more nozzles and/or one or more holes, which may receive at least part of a respective one of the nozzles. The or each hole may comprise a threaded portion and/or a pocket, e.g. an enlarged pocket. The pocket may be located at an end of the hole and/or may extend from a cavity plate facing surface of the melt distributor.

The threaded end of the gate pad may be received within, and/or be in threaded engagement with, one of the holes of the melt distributor, e.g. such that a nozzle tip extends into the nozzle seat. The shoulder of the gate pad may be received in the pocket. The shoulder may be annular and/or may be sized to provide a tight fit with the pocket, e.g. to maintain alignment of the gate pad relative to the melt distributor and/or nozzle.

The melt distributor may be mounted to the cavity plate, e.g. such that the outlet end of the gate pad is received within the gate pad receiving portion of the gate insert and/or such that the gate of the gate insert and the gate of the gate pad are aligned. The combined depth of the spigot, gate insert and flange may be less than that of the cavity plate.

At least one or each seat of the cavity plate may be fluidly connected to the cooling channel of the cavity insert via a cooling channel inlet, which may be on a first side of the seat, and/or a cooling channel outlet, which may be at

substantially the same depth as the cooling channel inlet and/or on a second side of the seat, which may be opposite the first side.

Another aspect of the invention provides a cavity plate, e.g. a preform cavity plate, comprising cooling channels described therein, a front face with an array of seats in fluid communication with the cooling channels for connection with respective cavity inserts, a rear face for mounting to a melt distributor and a depth described from the front face to the rear face, wherein each seat comprises a pair of cooling channel openings fluidly connected to the cooling channels at substantially the same depth.

Another aspect of the invention provides a mold, e.g. a preform mold, comprising an assembly or cavity plate as described above. The mold may comprise an injection mold, e.g. a preform injection mold.

Another aspect of the invention provides a molding system comprising a mold as described above. The molding system may comprise one or more of a melt distributor, an injection molding machine, a material supply system and a part removal and/or post mold cooling apparatus.

Another aspect of the invention provides a computer program element comprising and/or describing and/or defining a three-dimensional design for use with a simulation means or a three-dimensional additive or subtractive manufacturing means or device, e.g. a three-dimensional printer or CNC machine, the three-dimensional design comprising one or more mold components described above.

Another aspect of the invention provides a method of assembling an assembly as described above. The method may comprise one or more of inserting the gate insert into the gate insert seat of the cavity insert, inserting the retaining pin(s) into the threaded hole(s) of the spigot of the cavity insert and/or inserting the spigot of at least one of the cavity inserts into one of the seats in the cavity plate. Other steps and features of the method will be apparent to the skilled person.

Another aspect of the invention provides a method of molding articles. The method may comprise the use of one of the aforementioned mold stacks, molds, mold assemblies or molding systems. The method may comprise any one or more features or steps relevant to or involving the use of any feature of any of the aforementioned mold stacks, molds, mold assemblies or molding systems.

For the avoidance of doubt, any of the features described herein apply equally to any aspect of the invention. Within the scope of this application it is expressly intended that the various aspects, embodiments, examples and alternatives set out in the preceding paragraphs, in the claims and/or in the following description and drawings, and in particular the individual features thereof, may be taken independently or in any combination. That is, all embodiments and/or features of any embodiment can be combined in any way and/or combination, unless such features are incompatible. For the avoidance of doubt, the terms “may”, “and/or”, “e.g.”, “for example” and any similar term as used herein should be interpreted as non-limiting such that any feature so-described need not be present. Indeed, any combination of optional features is expressly envisaged without departing from the scope of the invention, whether or not these are expressly claimed. The applicant reserves the right to change any originally filed claim or file any new claim accordingly, including the right to amend any originally filed claim to depend from and/or incorporate any feature of any other claim although not originally claimed in that manner.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will now be described by way of example only with reference to the accompanying drawings in which:

FIG. 1 depicts a preform mold assembly according to an embodiment of the invention;

FIG. 2 depicts the preform mold assembly of FIG. 1 with the melt distributor omitted;

FIG. 3 depicts the core plate assembly of the preform mold assembly of FIGS. 1 and 2 with one core omitted and another core assembly shown exploded;

FIG. 4 depicts an enlarged view of the region of FIG. 3 which includes the exploded core assembly;

FIG. 5 depicts a side view of part of the core plate assembly of FIGS. 3 and 4 illustrating the mounting of one of the cores to the core plate;

FIG. 6 depicts a section view through one of the core assemblies and an adjacent portion of the core plate to which the core assembly is secured;

FIG. 7 depicts a core cooling tube assembly of the core assembly of FIG. 6 shown from a first side;

FIG. 8 depicts the core cooling tube assembly of FIG. 7 shown from a second side;

FIG. 9 depicts an alternative, unitary core cooling tube assembly shown from a first side;

FIG. 10 depicts the core cooling tube assembly of FIG. 9 shown from a second side;

FIG. 11 depicts a section view along a central, axial plane through the core cooling tube assembly of FIGS. 9 and 10;

FIG. 12 depicts a further alternative, unitary core cooling tube assembly shown from a first side;

FIG. 13 depicts the core cooling tube assembly of FIG. 12 shown from a second side;

FIG. 14 depicts a section view along a central, axial plane through the core cooling tube assembly of FIGS. 12 and 13;

FIG. 15 depicts a yet further alternative, unitary core cooling tube assembly shown from a first side;

FIG. 16 depicts the core cooling tube assembly of FIG. 15 shown from a second side;

FIG. 17 depicts a section view along a central, axial plane through the core cooling tube assembly of FIGS. 15 and 16;

FIG. 18 depicts an alternative, two-part core insert for use in the preform mold assembly of FIGS. 1 and 2;

FIG. 19 depicts the two-part core insert of FIG. 18 in an exploded view;

FIG. 20 depicts a section view of a stack assembly incorporating the two-part core insert of FIGS. 18 and 19 along a central, axial plane;

FIG. 21 depicts the moving part of the preform mold assembly of FIGS. 1 and 2, including the core plate assembly and stripper plate assembly;

FIG. 22 depicts the stripper plate of the stripper plate assembly of the moving part shown in FIG. 21;

FIG. 23 depicts an exploded view of a pair of slides of the stripper plate assembly of FIG. 18;

FIG. 24 depicts three neck ring halves and their associated retaining assemblies that secure them to the slides;

FIG. 25 depicts an enlarged view of part of the stripper plate assembly of the moving half of FIG. 21 with the neck ring pairs omitted to expose the slides;

FIG. 26 depicts an enlarged view of FIG. 25 with the connecting bars omitted and illustrating the insertion of the guide shaft;

FIG. 27 depicts the cavity plate assembly of the preform mold assembly of FIGS. 1 and 2 with one of the cavity assemblies removed therefrom;

FIG. 28 depicts one of the cavity assemblies of the cavity plate assembly of FIG. 27;

FIG. 29 depicts the cavity insert of the cavity assembly of FIG. 28 with the gate insert omitted;

FIG. 30 illustrates the cooling channels in segment A-A of the cavity insert of FIG. 29;

FIG. 31 depicts the gate insert of the cavity assembly of FIG. 28;

FIG. 32 depicts one of the retaining pins of the cavity assembly of FIG. 28;

FIG. 33 depicts a partial section view of the cavity plate assembly through a column of cavity inserts of the cavity plate assembly of FIG. 27;

FIG. 34 depicts a partial section view of the cavity plate assembly through a row of cavity inserts of the cavity plate assembly of FIG. 27;

FIG. 35 depicts an enlarged view of the bypass and retaining pin region of the partial section view of FIG. 34;

FIG. 36 depicts a similar view to FIG. 35 illustrating an alternative bypass channel configuration;

FIG. 37 depicts a similar view to FIGS. 35 and 36 illustrating an alternative retaining pin configuration in which the bypass channel is described between the retaining pin and the cavity insert;

FIG. 38 depicts a partial section view of the gate region of an alternative cavity plate assembly in which a gate pad is provided between the nozzle tip and gate insert;

FIG. 39 depicts an exploded view of the gate pad and gate insert of FIG. 38;

FIG. 40 depicts a partial section view of the mold of FIG. 1 illustrating one mold stack, but with the melt distributor and core cooling tube assembly both omitted;

FIG. 41 depicts an enlarged view of area B of FIG. 39 illustrating the gap between the stripper plate and the core plate;

FIG. 42 depicts the cavity plate assembly of FIG. 27 being lowered onto the moving part illustrated in FIG. 21 during assembly; and

FIG. 43 depicts part of the alignment procedure for aligning the cores and neck rings relative to the cavities of the cavity plate assembly.

DETAILED DESCRIPTION OF THE INVENTION

With reference to FIGS. 1 and 2, there is depicted a non-limiting embodiment of a preform mold assembly 100 according to the invention, which includes forty-eight cavities in this embodiment. The mold assembly 100 includes a first, moving part 110 for mounting to the moving platen (not shown) of an injection molding machine (not shown) and a second, stationary part 120 for mounting to the stationary platen (not shown) in the usual way. The first, moving part 110 includes a core plate assembly 200 and a stripper plate assembly 300. The second, stationary part 120 includes a cavity plate assembly 400 and a melt distributor 500, commonly referred to as a hot runner. In this embodiment, the melt distributor 500 is of a conventional type. This invention is particularly concerned with the product specific assembly 130 shown in FIG. 2, commonly referred to as the 'cold half' 130. The cold half 130 includes the core plate assembly 200, stripper plate assembly 300 and cavity plate assembly 400.

As shown more clearly in FIGS. 3 and 4, the core plate assembly 200 includes a core plate 210, a pair of cam plates 220, four guide pins 230 and a plurality of core assemblies 240. The core plate 210 is substantially rectangular in plan with scalloped corners 211, for accommodating the tiebars

(not shown) of an injection molding machine (not shown) within which the mold is mounted. The core plate **210** also includes four guide pin holes **212** through its thickness, which are horizontally inboard of each scalloped corner **211** and securely receive the guide pins **230**. The core plate **210** also includes a plurality of ejector holes **213** through its thickness, for accommodating ejector pins (not shown).

A network of cooling channels **214a**, **214b** is included within the core plate **210**, which feed into a plurality of cooling channel seats **215** in a front face CRF of the core plate **210** (as illustrated in FIG. 6). The cooling channel seats **215** are arranged in an array of six vertical columns and eight horizontal rows. Each seat **215** is surrounded by three core mounting holes **216**, which extend through the thickness of the core plate **210** and are counterbored on a rear face CRR of the core plate **210**. An array of coupling bolts **217** are also inserted into holes in the core plate **210**, which are also counterbored on the rear face CRR. One of the cam plates **220** is bolted to a central, lower region of the front face CRF of the core plate **210** and includes a pair of cam slots **221** on its upper surface. The other cam plate **220** is bolted to a central, upper region of the front face CRF of the core plate **210** and includes a similar pair of cam slots **221** on its lower surface. Both cam plates **220** have the same configuration, varying only in their orientation. The cam slots **221** of each cam plate **220** extend perpendicularly from the front face CRF and converge toward the free end of the cam plate **220**.

As illustrated more clearly in FIGS. 4 to 8, each core assembly **240** includes a hollow core insert **250** and a core cooling tube assembly **260**, **270**. In this example, the core cooling tube assembly **260**, **270** includes a coolant diverter **260** received in one of the cooling channel seats **215** of the core plate **210** and a core cooling tube **270** releasably secured to the coolant diverter **260** and received within the hollow core insert **250**.

Each core insert **250** includes a substantially cylindrical base **251** and a molding portion **252** joined to the base **251** by a taper **253**. The molding portion **252** has an outer molding surface **252a**, for molding an inner surface of a preform in the usual way, a tapering transition region **252b** for molding a transition region between neck and body regions of the preform and a top sealing surface portion TSS for molding part of the top sealing surface of a preform. The core taper **253** extends from the top sealing surface portion TSS to a front surface **251a** of the base **251** and includes a single, male taper **253** for a stack configuration known in the art as a so-called 'cavity-lock' design. However, it will be appreciated that the core insert **250** may be of the so-called 'core-lock' design without departing from the scope of the invention.

In this example, each core insert **250** includes a substantially planar mounting surface **254** and three threaded blind holes **255** extending from the mounting surface **254**. The core inserts **250** are therefore mounted from the rear, or rear mounted, whereby bolts **218** are inserted into the core mounting holes **216** from the rear face CRR of the core plate **210** and threadedly engage the threaded holes **255** of the core inserts **250**. This is illustrated in FIG. 5. This rear mounting enables the core inserts **250** to be secured from the rear of the core plate **210**. As such, the pitch between the core inserts **250** can be reduced without obstructing access to the bolts **218**, as would be the case with traditional core inserts having a flange with through holes for receiving front mounted bolts **218**.

As discussed in more detail below, this rear mounting, in combination with the substantially planar mounting surface

254, also enables the core inserts **250** to be mounted loosely to the front face CRF of the core plate **210** in a floating manner and fixed securely relative thereto after the mold **100** or cold half **130** is fully assembled. More specifically, by loosely tightening the bolts **218**, the clearances between them and the core mounting holes **216** allow a degree of sliding movement between the mounting surfaces **254** of the core inserts **250** and the front face CRF. The mounting surface **254** describes a terminal end of the core insert **250** and is free of any projections, thereby to enable the core inserts **250** to slide relative to the core plate **210**. With the mold **100** or cold half **130** in an assembled condition, the bolts **218** are still accessible from the rear face CRR of the core plate **210** and can therefore be torqued to fix the core inserts **250** securely to the core plate **210**.

It is also envisaged, however, that the core insert **250** could be provided with a spigot that extends from the mounting surface **254**. In some cases, the spigot (not shown) could be smaller than the seat **215** in the core plate **210** to enable some sliding movement therebetween. In other examples, the spigot may be substantially the same size as the seat **215** in the core plate **210**.

Referring now to FIG. 6, each core insert **250** includes a central bore **250a** extending from the mounting surface **254** to a hemispherical or domed, closed end adjacent the free end of the molding portion **252**. The central bore **250a** includes a tapering, intermediate region **250b** corresponding to the tapering transition region **252b** of the outer molding surface **252a**. As such, the wall thickness between the central bore **250a** and the outer molding surface **252a** remains substantially constant along the entire molding portion **252**. The mounting surface **254** also includes a shallow recess **256** surrounding the central bore **250a** and defining therebetween a shutoff surface **257**. The shutoff surface **257** also includes an O-ring groove **258** between the recess **256** and the central bore **250a**, within which an O-ring **259** is received for sealing the interface between the central bore **250a** and the core plate **210**.

Each coolant diverter **260**, shown in FIGS. 6 to 8, is substantially cylindrical and includes an axial blind bore **261**, a radial bore **262** orthogonal to the axial bore **261** and a peripheral recess **263** parallel to the axial bore **261**. The axial bore **261** extends from an upper surface **264** of the diverter **260** and terminates adjacent a lower surface **265** thereof. The axial bore **261** includes an enlarged portion **261a** extending from the upper surface **264** and is threaded along part of its length to provide a connector for the core cooling tube **270**. The radial bore **262** extends from the blind end of the axial bore **261** to a circumferential surface **266** on the opposite side of the diverter **260** to the peripheral recess **263**. The axial bore **261** and radial bore **262** together provide a first cooling channel **261**, **262** of the coolant diverter **260**.

The peripheral recess **263** extends about approximately half of the circumference of the diverter **260** from the upper surface **264** toward the lower surface **265**, terminating on an opposite side to the axial bore **261** such that the circumferential surface **266** extends around the entire periphery of the lower end of the diverter **260**. The peripheral recess **263** cooperates with a facing surface of the cooling channel seat **215** to describe a second cooling channel of the coolant diverter **260**, with an inlet described at the front face CRF of the core plate **210** and an outlet corresponding to the opening of the facing cooling channel **214b** in the cooling channel seat **215**.

Each coolant diverter **260** also includes a locator in the form of a retaining lip **267**, which projects from the circumferential surface **266** about the periphery of the opening of

the radial bore **262**. The coolant diverter **260** is formed of a resilient plastics material, such that the retaining lip **267** is resiliently deformable. As such, insertion of the diverter **260** into the cooling channel seat **215** causes the retaining lip **267** to deform resiliently until both the depth and orientation of the diverter **260** within the cooling channel seat **215** are such that the radial bore **262** is aligned with a facing cooling channel **214a**. Upon alignment between the radial bore **262** and the cooling channel **214a**, the retaining lip **267** snaps into the cooling channel **214a** and returns to its original shape. As a result, the retaining lip **267** provides a snap fit connector, acting both as a locating means, ensuring proper alignment of the radial bore **262** and cooling channel **214a**, and as a retaining means for retaining the diverter **260** within the cooling channel seats **215**. In this orientation, the peripheral recess **263** is aligned with a cooling channel **214b** on the opposite side of the cooling channel seat **215**. Whilst the retaining lip **267** is a convenient and preferred configuration, it may be replaced with a depression for receiving a projection on a facing surface of the cooling channel seat **215**.

Each core cooling tube **270** includes first, second and third tubular segments **271**, **272**, **273**. The first tubular segment **271** has a first outer diameter, the second tubular segment **272** has a second outer diameter, larger than the first outer diameter, and the third tubular segment **273** has a third outer diameter between the first and second outer diameters. The second tubular segment **272** also includes tapered ends **272a**, **272b**, which provide a transition between the three diameters. The outer surfaces of the second and third segments **272**, **273** correspond broadly to the profile of the central bore **250a** of the core insert **250** within which the core cooling tube **270** is received, which is configured to provide a predetermined flow area between the outer surface of the core cooling tube **270** and the central bore **250a** to maximise cooling effectiveness.

The first tubular segment **271** includes an externally threaded lower end **271a**, which is received within, and threadedly engages the internal threads of, the enlarged axial bore portion **261a** of one of the coolant diverters **260**. The inner diameter of the second tubular segment **272** is larger than that of the first tubular segment **271**, an upper end of which is received in the second tubular segment **272**. The inner diameters of the second and third tubular segments **272**, **273** are substantially the same. The third tubular segment **273** is secured at its lower end to the second tubular segment **272** and includes an upper, free end which has a jagged-toothed profile including four pointed teeth **273a**. The third tubular segment **273** also includes spacing vanes **273b** in an intermediate portion thereof, adjacent but spaced from the teeth **273a** and aligned between each pair of teeth **273a**.

The teeth **273a** ensure that any unintended forward movement of the core cooling tube **270** caused by fluid pressure flowing therethrough does not close off the flow between the core cooling tube **270** and the internal, domed end of the central bore **250a** of the core insert **250**. The spacing vanes **273b** ensure that the core cooling tube **270** is also located centrally within the core insert **250**. These spacing vanes **273b** are configured to restrict radial movement of the core cooling tubes **270** by engaging against facing surfaces of the central bore **250a** of the core insert **250**. This arrangement maintains the position of the core cooling tube **270** within the central bore **250a**, thereby ensuring that the flow profile of the cooling fluid is distributed substantially evenly therealong.

The flow direction of cooling fluid from the cooling channels **214a**, **214b** is indicated by the arrows in FIG. 6. As

shown, cooling fluid flows from a first, inlet cooling channel **214a** into the radial bore **262** of the coolant diverter **260**, which acts as an inlet portion of first cooling channel **261**, **262**, then flows up and out of the axial bore **261**, which acts as an outlet portion. The cooling fluid then flows through and out of the core cooling tube **270** to impact the center of the domed end of the central bore **250a** of the core insert **250**. The domed end of the core insert **250** then causes the flow to reverse, in an umbrella-like fashion to the annular gap between the outer surface of the core cooling tube **270** and the central bore **250a**. However, it will be appreciated that the cooling fluid flow could otherwise flow through in the opposite direction.

The outer surface of the core cooling tube **270** corresponds broadly to the profile of the central bore **250a** of the core insert **250** within the molding portion **252**, thereby to provide a predetermined annular flow area, which is less than the flow area within the core cooling tube **270**. As such, the cooling fluid is throttled along this annular flow area to create a turbulent flow to increase heat transfer between the molding portion **252** and the cooling fluid. The cooling fluid then flows into the peripheral recess **263** of the coolant diverter **260** and out of the cooling channel **214b** on the opposite side of the cooling channel seat **215**. As such, the peripheral recess **263** acts as an outlet for the cooling fluid back into the network of cooling channels **214a**, **214b**.

The coolant diverter **260** is formed of a resilient plastics material, such as by molding or additive manufacturing. However, the skilled person will appreciate that it is also possible to form the coolant diverter **260** from a different, more rigid plastics or metallic material, with the retaining lip **267** being provided either as an insert made of a resilient material or formed by overmolding the body of the coolant diverter **260** with a resilient material. In addition, the core cooling tube **270** is formed of stainless steel, with the tubular segments **271**, **272**, **273** and spacing vanes **273b** being brazed together. However, the core cooling tube **270** may instead be formed as a unitary body, such as by an additive manufacturing technique. The core cooling tube **270** may be formed of a different material, which may be a metallic or plastics material, and/or may be formed by any other suitable process.

FIGS. 9 to 11 illustrate an alternative core cooling tube assembly **1260**, **1270**, which is similar to the core cooling tube assembly **260**, **270** described above, wherein like features are labelled with like references with the addition of a preceding '1'. As shown, this core cooling tube **1270** differs, inter alia, in that the first, second and third tubular segments **1271**, **1272**, **1273** and the coolant diverter **1260** are all formed integrally. The third tubular segment **1273** of the core cooling tube **1270** also includes an open end **1273a** described by a truncated dome **1273a**, in place of the jagged-toothed end of the core cooling tube **270** described above.

The provision of a jagged-toothed end is not necessary in this example, since the core cooling tube **1270** and coolant diverter **1260** are integral in this example and there is little risk of separation. In addition, the truncated dome **1273a** includes an aperture A having a smaller diameter than the bore in the third tubular segment **1273**, thereby describing a flow area which is less than the flow area through the third tubular segment **1273**. As a result, cooling fluid flowing through the core cooling tube **1270** accelerates as it flows out through the aperture A. This configuration also focuses the flow directly toward a central region of the domed end of the central bore **250a** of the core insert **250**, before the flow is reversed as described above. This reduction in flow area to

provide an accelerated, directed flow has been found to improve cooling performance.

In contrast, the teeth **273a** in the core cooling tube **270** described above provide an effective increase in the flow area as compared with the flow area through the third tubular segment **273**. Indeed, some of the flow of coolant fluid from the third tubular segment **273** will exit through the spaces between the teeth **273a** and be entrained with the reversed flow through the annular gap between the outer surface of the core cooling tube **270** and the central bore **250a** of the core insert **250**, thereby avoiding the domed end of the central bore **250a** of the core insert **250**.

It will be appreciated by those skilled in the art that this, end region of the core insert **250** is exposed to the highest temperatures, since molten plastic introduced into the cavity impinges directly on it during the molding process. As such, the reduction in flow area and directed flow toward this region of the core insert **250**, which are provided by the core cooling tube **1270** according to this example, are particularly beneficial.

The coolant diverter **1260** is a continuation of the first tubular segment **1271**, with a gradual, curved tubular transition portion **1263** between the axial bore **1261** and the radial bore **1262**. The coolant diverter **1260** also includes three spacer fins **1266**, which center it within the cooling channel seat **215** of the core plate **210**. The radial bore **1262** and curved transition joining it to the axial bore **1261** are formed by the tubular transition portion **1263**, which has a substantially constant thickness, thereby maximizing the flow area around the coolant diverter **1260**, as compared with the shallow recess **263** of the coolant diverter **260** shown in FIGS. **6** to **8**. This alleviates the flow restriction created by the recess **263**, thereby reducing the pressure drop as the cooling fluid travels out of the core insert **250** back into the network of cooling channels **214a**, **214b**.

A retaining lip **1267** is formed by a tapered end of the tubular transition portion **1263**, which functions in a similar manner to the retaining lip **267** described above. The integral structure is formed of a suitable plastics material, which is sufficiently resilient to enable the retaining lip **1267** to deform resiliently upon insertion of the coolant diverter **1260** into the cooling channel seat **215**, to snap into the cooling channel **214a** and return to its original shape. However, the core cooling tube **1270** should be formed of a material that is also sufficiently rigid for it to retain its shape under the pressure of the cooling fluid. In an effort to mitigate the effects of any deformation of the core cooling tube **1270**, the second tubular segment **1272** includes three spacing vanes **1272c** spaced equally about its periphery and the third tubular segment **1273** includes six spacing vanes **1273b** spaced equally about its periphery, with every other spacing vane **1273b** being staggered axially with respect to adjacent spacing vanes **1273b**. Of course, it is also possible that different parts of the integral structure are formed with different materials, thereby to provide additional rigidity where it is needed. It is preferred that the coolant diverter **2260** and core cooling tube **2270** are formed integrally to provide a seamless unitary monolithic structure. This can be via an additive manufacturing process, for example and without limitation.

Turning now to FIGS. **12** to **14**, there is shown a further alternative core cooling tube assembly **2260**, **2270**, which is similar to the core cooling tube assembly **1260**, **1270** described immediately above, wherein like features are labelled with like references with the preceding '1' replaced with a preceding '2'. As shown, this core cooling tube **2270** differs in that the third tubular segment **2273** only includes

three spacing vanes **2273b**, which are aligned axially and distributed evenly about the periphery of the third tubular segment **2273**.

In addition, the coolant diverter **2260** includes a part-circumferential wall **2268**, with an outer surface akin to the circumferential surface **266** of the core cooling tube **270** according to the first example, but a retaining lip is not shown. This, part-circumferential wall **2268** is spaced from the main body of the coolant diverter **2260**, which defines the axial bore **2261**, and cooperates with the facing surface of the cooling channel seat **215** of the core plate **210** to provide a substantially sealed connection between the radial bore **2262** and the facing cooling channel **214a**. Whilst no retaining lip is shown in FIGS. **12** to **14**, the skilled person will appreciate that such a retaining lip may be incorporated in this example.

The coolant diverter **2260** also includes a spacer fin **2266** on the opposite side to the part-circumferential wall **2268**. As such, spacer fin **2266** and the part-circumferential wall **2268** together center the coolant diverter **2260** within the cooling channel seat **215** of the core plate **210**. In addition, the bottom of the coolant diverter **2260** is provided with a locating spigot **2265** having a notch **2265a** in its lower surface. The locating spigot **2265** is received in a locating recess (not shown) in the base of a variation of the cooling channel seat **215** of the core plate **210** shown in FIG. **6**. The locating recess (not shown) also includes a projection, which engages the notch **2265a** to ensure orientational alignment between the radial bore **2262** and the facing cooling channel **214a**. Whilst the notch **2265a** does not provide a retaining means in this example, it may be replaced with a radial projection that engages a facing depression in the locating recess (not shown) to provide both a locating means and a retaining means.

The tubular transition portion **2263** is joined to the part-circumferential wall **2268** about the inlet to the radial bore **2262**. As such, the coolant diverter **2260** according to this example more rigidly secures the core cooling tube **2270** in the cooling channel seat **215** of the core plate **210** as compared with the coolant diverter **1260** according to the second example, whilst minimizing the reduction in flow area around the tubular transition portion **2263**. As such, this arrangement maintains substantially the advantages mentioned above in relation to the coolant diverter **1260** according to the second example, namely reducing the pressure drop as the cooling fluid travels out of the core insert **250** back into the network of cooling channels **214a**, **214b**.

FIGS. **15** to **17** illustrate yet a further alternative core cooling tube assembly **3260**, **3270**, which is similar to the core cooling tube assembly **2260**, **2270** described immediately above, wherein like features are labelled with like references with the preceding '2' replaced with a preceding '3'. As shown, this core cooling tube assembly **3260**, **3270** differs only in that the part-circumferential wall **3268** of the coolant diverter **3260** is joined to the main body which defines the axial bore **3261** by webs **3264a**, **3264b** about its periphery. More specifically, the upper edge of the part-circumferential wall **3268** is joined to the main body by an annular web **3264a** and the axial side edges of the part-circumferential wall **3268** are joined to the main body by a respective axial web **3264b**. This produces a cavity between the part-circumferential wall **3268**, the main body and the webs **3264a**, **3264b**.

This arrangement improves further the rigidity of the engagement between the core cooling tube **3270** and the cooling channel seat **215** of the core plate **210**. However, the resulting reduction in flow area around the tubular transition

portion **3263** increases the pressure drop as the cooling fluid travels out of the core insert **250** back into the network of cooling channels **214a**, **214b**, as compared to the core cooling tubes **1270**, **2270** according to the second and third examples. As with the core cooling tube **2270** according to the third example, a retaining lip may be incorporated in this example.

An alternative, two-part core insert **1250** is shown in FIGS. **18** to **20**, which can be used in the preform mold assembly **100** in place of the aforementioned core insert **250**. The two-part core insert **1250** is similar to the core insert **250** described above, wherein like features are labelled with like references with the addition of a preceding '1'. As shown, this, two-part core insert **1250** differs from the core insert **250** described above in that it includes a primary core insert **1250a** and a core ring **1250b**.

In this example, the forwardmost part of the base **1251** of the primary core insert **1250a** is recessed to provide a front face **1251a** and an interface portion **1251b** projecting from the front surface **1251a**. The core ring **1250b** includes a base portion **1251'** or flange **1251'** with a front surface **1251a'** corresponding to the front surface **251a** of the core insert **250** described above. The core ring **1250b** also includes an internal interface surface **1251b'** and a male taper **1253** corresponding to the male taper **253** of the core insert **250** described above. The interface portion **1251b** is received by the core ring **1250b** in contact with the internal interface surface **1251b'** thereof in a press-fit condition.

As illustrated more clearly in FIG. **20**, the provision of a core ring **1250b** provides a venting path from the inner corner of the neck opening of the preform cavity, between the primary core insert **1250a** and the core ring **1250b**. This enables the parting line between the two-part core insert **1250** and split mold inserts **350**, or neck rings **350**, to be moved from the top sealing surface to the outer corner of the neck opening. The reasons for this and its significance will be immediately apparent to the skilled addressee. In this example, the core ring **1250b** includes a pair of vent passages CRV extending from the internal interface surface **1251b'** to a collector groove CG define through the outer surface of the male taper **1253**. In operation, air venting through the vent passages is directed by the collector groove CG to which is aligned with a lower vent passages LNRV defined on mating faces of through the neck ring **350**. As shown the neck ring **350** further includes upper vent passages UNRV defined on the mating faces thereof.

Turning now to FIG. **21**, the moving part **110** of the mold assembly **100** is shown in isolation, with the cavity plate assembly **400** omitted to expose features of the stripper plate assembly **300**. The stripper plate assembly **300** includes a stripper plate **310**, six slide pairs **320** slidably mounted to the stripper plate **310**, upper and lower guide assemblies **330**, which guide the movement of the slide pairs **320** along the stripper plate **310** and four connecting bars **340**. In this example, the mold stack includes a plurality of split mold inserts **350**, or neck rings **350**, arranged in pairs and mounted on the slides **320** for movement therewith.

The stripper plate **310**, which is shown more clearly in FIG. **22**, is substantially rectangular in plan with scalloped corners **311**, which are aligned with the scalloped corners **211** of the core plate **210** for accommodating the tiebars (not shown) of an injection molding machine (not shown) within which the mold is mounted. The stripper plate **310** also includes four guide pin bushings **312** with associated holes (not shown) through its thickness, which are horizontally inboard of each scalloped corner **311** for receiving the guide pins **230** of the core plate **210**. The stripper plate **310** also

includes a plurality of core insert holes **313** through its thickness, upper and lower cam plate holes **314** and ten wear or bearing plates **315**, hereinafter bearing plates **315**, which provide bearing surfaces along and against which the slides **320** move along the stripper plate **310**.

Each guide pin bushing **312** is in the form of a hollow cylinder and is bolted to the stripper plate **310** by four bolts **312a**. Each guide pin bushing **312** also includes a grease nipple **312b** for introducing grease onto the inner surface thereof in the usual way. The internal diameter of the guide pin bushings **312** provides a small gap between the guide pins **230** and guide pin bushings **312** within which grease introduced via the grease nipple **312b** is received, such that the guide pins **230** slide freely within the guide pin bushings **312** to support the stripper plate **310** during movement between it and the core plate **210** in the usual way.

The core insert holes **313** are arranged in an array of six vertical columns and four horizontal rows and each is configured to accommodate the base **251** of one of the core inserts **250**. Each core insert hole **313** is sized to provide a clearance between it and the core insert base **251** in order to prevent contact between them as the stripper plate **310** is moved toward and away from the core plate **210** along the guide pins **230**. The cam plate holes **314** are obround in shape and configured to accommodate the cam plates **220**. Each cam plate hole **314** is sized to provide a clearance between it and the cam plate **220** in order to prevent contact between them as the stripper plate **310** is moved toward and away from the core plate **210** along the guide pins **230**. A pair of threaded guide bracket mounting holes **330a** are included between each column of the core insert holes **313**, both at the top and the bottom of the stripper plate **310**. A pair of guide bracket dowels **330b** are also included between each pair of guide bracket mounting holes **330a**.

The bearing plates **315**, which may also be referred to as wear plates **315**, are formed of a wear resistant material. Each bearing plate **315** is substantially rectangular in plan and includes two holes **316** through its thickness and four part-circular cut-outs **317a**, **317b**. The pitch spacing of the bearing plate holes **316** corresponds to the pitch spacing of the core insert holes **313** along each vertical column. Two of the part-circular cut-outs **317a** are at the center of the short edges of the bearing plate **315** and the pitch spacing of each part-circular cut-out **317a** and its adjacent bearing plate hole **316** also corresponds to the pitch spacing of the core insert holes **313** along each vertical column. The other two part-circular cut-outs **317b** are at the center of the long edges of the bearing plate **315**. As such, the bearing plates **315** are symmetrical about a central, longitudinal axis.

The bearing plates **315** are placed lengthwise along one of the vertical columns, with the bearing plate holes **316** and part-circular cut-outs **317a** aligned with the core insert holes **313**. Three bearing plates **315** are mounted along each of the two central columns of core insert holes **313**, whilst a single bearing plate **315** is mounted at the vertical center of the four outermost columns. In the mold according to this disclosure, bearing plates **315** are selectively positioned to provide balanced support for the slide pairs **320** during ejection, whilst minimising their number to reduce cost. This is made possible by virtue of the load paths which result from the overall design of the mold assembly **100**, which is discussed below.

Each slide pair **320**, shown more clearly in FIG. **23**, includes first and second slides **320a**, **320b**, which have essentially the same design. Each slide **320a**, **320b** is in the form of a bar having a substantially square or near-square cross-section, with a plurality of semi-circular cut-outs **321**

along one of its sides and a guide hole 322 at each of its ends 323a, 323b and extending from one side through to the other side. A guide bushing 322a is received in each of the guide holes 322 and is retained therein by an interference fit, although other arrangements are also envisaged. The centermost slides 320a, 320b also include a cam follower 324 (shown in FIG. 25) at each end 323a, 323b. Each cam follower 324 is in the form of a roller, which is rotatably mounted to the slide end 323a, 323b for receipt within one of the cam slots 221 of one of the cam plates 220.

Each slide 320a, 320b also includes, in its front face, a first pair of connecting bar mounting holes 325a at a first end 323a, a second pair of connecting bar mounting holes 325b adjacent, but spaced from, a second end 323b, a series of neck ring mounting hole 326 and a series of cooling channel ports 327. One of the neck ring mounting holes 326 is located between each of the semi-circular cut-outs 321 and a further neck ring mounting hole 326 is located on the outer side of each of the semi-circular cut-outs 321 adjacent the ends 323a, 323b of the slide 320a, 320b. In use, the neck rings 350 are mounted to the slides 320a, 320b by the neck ring mounting holes 326 such that the cooling channel ports 327 are aligned with cooling channel ports (not shown) on a facing surface of the neck rings 350. Each cooling channel port 327 includes an O-ring 327a (shown in FIG. 26) for sealing against the neck rings 350. The cooling channel ports 327 are connected to a network of cooling channels (not shown), which are connected to a source of cooling fluid in the usual way.

In this example, the neck rings 350 are secured to the slides 320a, 320b in a floating manner by a retainer assembly of the kind described in our co-pending application number PCT/CA2018/050693, which is incorporated herein by reference. More specifically and as shown in FIG. 24, each neck ring 350 is formed of a pair of neck ring halves 350a, 350b. A plurality of neck ring halves 350a are up positioned longitudinally adjacent to each other on one slide 320a and a corresponding plurality of neck ring halves 350b are positioned longitudinally adjacent to each other on an opposed slide 320b. Each neck ring half 350a, 350b is generally configured conventionally, but is configured to be secured to a slide 320a, 320b with two retainer mechanisms 351.

Each retainer mechanism 351 includes a retainer member in the form of a bolt 352 and an insert member 353. Each bolt 352 has a head portion 352a and a threaded shaft portion 352b. Each insert member 353 has an upper annular flange portion 353a, a cylindrical body portion 353b extending axially from the flange portion 353a and a cylindrical opening extending axially through the flange portion 353a and the body portion 353b. The bolt 352 is received within the cylindrical opening of the insert member 353 and threadedly engages the neck ring mounting holes 326 to retain the insert member 353 between the bolt 352 and facing surface of the slide 320a, 320b. This results in a fixed spacing between the flange portion 353a of the insert member 353 and the facing surface of the slide 320a, 320b.

Each neck ring half 350a, 350b has a semi-cylindrical central opening 354 such that, when a pair of neck ring halves 350a, 350b are brought together during operation of an injection molding system, the inward surfaces providing opening 354 of the neck ring halves 350a, 350b will define the profile for a neck region of a preform to be molded. Each neck ring half 350a, 350b will be held to a corresponding slide 320a, 320b by a pair of retainer mechanisms 351 at each longitudinal side of the neck ring half 350a, 350b. Each neck ring half 350a, 350b includes an upper, generally

arcuate, half-ring portion 355a and a flange portion 355b. The half-ring portion 355a has a tapered side surface 355c and the flange portion 355b has a lower surface 355d and an inner taper surface 355e.

Each neck ring half 350a, 350b also has a pair of longitudinally opposed, generally stepped, semi-cylindrical side apertures 356. Each aperture 356 has a passageway that passes all the way through the flange portion 355b of the neck ring half 350a, 350b. When a pair of neck ring halves 350a, 350b are positioned longitudinally adjacent to each other on a slide 320a, 320b, a cylindrical opening is formed by the two adjacent, facing apertures 356. This opening is configured to receive one of the retainer mechanism 351 and includes a recessed platform described by the step in the facing apertures 356. The depth of this, recessed platform is specifically provided to position the flange portion of 353a of the insert member 353 such that a gap is formed between the lower surface of the flange portion 353a and the upward facing opposite surface of the recessed platform. This gap may be in the range of 0.01 to 0.03 mm, by way of example.

When the neck ring halves 350a, 350b are mounted to the slides, the pressure exerted on the flange portions 355b by the O-rings 327a urges them away from the slide 320a, 320b. The aforementioned gap between the lower surface of the flange portion 353a and the upward facing opposite surface of the recessed platform formed by the stepped side apertures 356 allows a slight (e.g. 0.01 to 0.03 mm) gap to form between the neck ring halves 350a, 350b and the front face of the slides 320a, 320b. This gap enables a degree of sliding, or floating, of the neck ring halves 350a, 350b relative to the slides 320a, 320b, whilst exerting sufficient compression of the O-rings 327a to maintain the sealed interface between the cooling channel ports 327 and the facing cooling channel ports (not shown) of the neck ring halves 350a, 350b.

As such, the neck ring halves 350a, 350b are capable of a degree of sliding movement relative to their respective slides 320a, 320b as the mold halves are brought together. This allows the pairs of neck ring halves 350a, 350b to be repositioned, thereby assisting in proper alignment with the rest of the mold stack. However, it is also envisaged that traditional, non-floating neck rings (not shown) may be used, which is described in more detail below.

FIGS. 25 and 26 illustrates the interconnection between the slide pairs 320 and the stripper plate 310, including one of the guide assemblies 330 and one pair of connecting bars 340. The guide assembly 330 includes a guide shaft 331 having a round cross-section and secured to the stripper plate 310 by seven guide brackets 332. The upper guide assembly 330 is mounted across an upper region of the stripper plate 310, immediately below the upper scalloped corners 311 and guide pin bushings 312. The lower guide assembly 330 is similarly mounted across a lower region of the stripper plate 310, immediately above the lower scalloped corners 311 and guide pin bushings 312.

Each of the upper and lower guide assemblies 330 includes a guide bracket 332 mounted between each slide pair 320 and end guide brackets 332 mounted adjacent each scalloped corner 311. The guide brackets 332 fix the guide shaft 331 in place. Each guide bracket 332 includes a base 333, a clamp member 334 and a pair of bolts 335 received within respective bolt holes 336 in each of the base 333 and clamp member 334. As illustrated in FIG. 26, each guide assembly 330 is assembled by inserting the guide shaft 331 through the guide bushings 322a at one end 323a, 323b of the slides 320a, 320b with the guide bracket base 333 held in place by the guide bracket dowels 330b. The guide

bracket clamp members **334** are then placed over the guide shaft **331** and the bolts **335** are inserted into the bolt holes **336** in each of the guide bracket base **333** and clamp member **334**. The bolts **335** are threadedly engaged with the guide bracket mounting holes **330a** to secure the guide bracket clamp member **334** to the stripper plate **310** and to clamp the guide shaft **331** between the guide bracket clamp member **334** and base **333**. As a result, the slides **320a**, **320b** are retained against the bearing plates **315** of the stripper plate **310**, such that they are slidable along the guide shafts **331** and bearing plates **315**.

The connecting bars **340** in this example are elongate with a square cross-section and each has six pairs of bolt holes **341** spaced along its length. Bolts **342** are received in each bolt hole **341** and secure the connecting bars **340** to one of the slides **320a**, **320b** of each slide pair **320**, although only one bolt **342** is illustrated in each pair of bolt holes **341** in FIG. **25**. One of the connecting bars **340** is connected to the first slide **320a** of each slide pair **320** and the other of the connecting bars **340** is connected to the second side **320b** of each slide pair **320**. As such, sliding movement of one of the first slides **320a** causes all of the first slides **320a** to move therewith. Similarly, sliding movement of one of the second slides **320b** causes all of the second slides **320b** to move therewith.

In use, forward movement of the stripper plate **310** away from the core plate **210** causes the cam followers **324** to move along the cam slots **221**, which causes the slides **320a**, **320b** carrying the cam followers **324** to slide along the guide shafts **331** and bearing plates **315** toward one another. This, in turn, causes each of the slide pairs **320** to move away from one another, sliding along the guide shafts **331** and bearing plates **315**, to open the neck rings and in so doing eject preforms from the cores in the usual way. Similarly, rearward movement of the stripper plate **310** towards the core plate **210** causes the cam followers **324** to follow a reverse path along the cam slots **221**, thereby closing the neck rings.

Turning now to FIG. **27**, the cavity plate assembly **400** includes a cavity plate **410**, four guide pin bushings **420** and a plurality of cavity assemblies **430**. The cavity plate **410** is substantially rectangular in plan with a front face CVF, a rear face CVR and scalloped corners **411**. The scalloped corners **411** are aligned with the scalloped corners **211**, **311** of the core and stripper plates **210**, **310**, when the mold **100** is in an assembled condition, for accommodating the tiebars (not shown) of an injection molding machine (not shown) within which the mold is mounted. The cavity plate **410** includes guide pin holes (not shown) through its thickness, which are aligned with the guide pin bushings **420** and are horizontally inboard of each scalloped corner **411** for receiving the guide pins **230** of the core plate **210**.

The cavity plate **410** also includes a plurality of seats **412** through its thickness, a network of cooling channels **413a**, **413b**, **413c** in communication with the seats **412** and upper and lower cam plate holes **414** through its thickness. The seats **412** are arranged in an array of six vertical columns and eight horizontal rows, arranged to match the core inserts **250**. Each seat **412** is surrounded by four threaded cavity mounting holes **415**, wherein one of the cavity inserts **430** is received in each seat **412** and is secured to the cavity plate **410** by bolts **416**, which threadedly engage the cavity mounting holes **415**. The cam plate holes **414** are obround in shape and configured to accommodate the cam plates **220**. Each cam plate hole **414** is sized to provide a clearance between it and the cam plate **220** in order to prevent contact between them as the mold **100** closes. The cavity plate **410** also includes an array of coupling bolt holes **417** for receiv-

ing the aforementioned coupling bolts **217** to secure the cavity plate **410** to the core plate **210**, which is described further below.

Each guide pin bushing **420** is in the form of a hollow cylinder and is bolted to the cavity plate **410** by four bolts **421**. Each guide pin bushing **420** also includes a grease nipple **422** for introducing grease onto the inner surface thereof in the usual way. The internal diameter of the guide pin bushings **420** provides a small gap between the guide pins **230** and guide pin bushings **420** within which grease introduced via the grease nipple **422** is received, such that the guide pins **230** slide freely within the guide pin bushings **420** to ensure proper alignment between the core and cavity plates **210**, **410** during operation in the usual way.

As illustrated more clearly in FIGS. **28** to **35**, each cavity assembly **430** includes a cavity insert **440**, a gate insert **450** and a pair of retaining pins **460**. In this example, the cavity insert **440** and gate insert **450** are separate components, but in other variations they may be formed as a single unitary structure. The cavity insert **440** includes a substantially cylindrical body **441** with flat sides **442** to provide a substantially obround cross-section. The cavity insert **440** also includes a spigot **443** projecting from a mounting face **441a** at one end of the body **441**, four axial mounting holes **444** adjacent the outer corners of the substantially obround cross-section, which extend from the mounting face **441a** to a front face **441b** at the opposite end of the body **441**, and a network of cooling channels **445**.

The spigot **443** is hollow, with a stepped gate insert seat **446** for receiving the gate insert **450**. The body **441** of the cavity insert **440** is also hollow and includes a female taper **447** extending from the front face **441b** to a molding surface **448**. The body **441** includes an annular step **447a** joining the taper **447** to the molding surface **448**, which extends therefrom to the gate insert seat **446**. The gate insert seat **446** includes a first portion **446a**, cylindrical, which extends from an end face **443a** of the spigot **443** to a first internal shoulder **443b**, and a second portion **446b**, also cylindrical, having a smaller diameter than the first portion **446a**, which extends from the first internal shoulder **443b** to a second internal shoulder **443c**. The first internal shoulder **443b** provides a transition from the first portion **446a** of the gate insert seat **446** to its second portion **446b**, while the second shoulder **443c** provides a transition from the second portion **446b** of the gate insert seat **446** to the molding surface **448** of the body **441**.

The spigot **443** includes a pair of threaded, radial holes **449** extending from the first portion **446a** of the gate insert seat **446** to an outer circumferential surface of the spigot **443**. The axis of the radial holes **449** is parallel to the flat sides **442** and their bases are substantially flush with the first internal shoulder **443b** of the gate insert seat **446**. The spigot **443** also includes a circumferential groove **443d** in its outer, circumferential surface, below the radial holes **449**, for accommodating an O-ring seal (not shown).

The network of cooling channels **445** includes a coolant inlet **445a** and a coolant outlet **445b** each fluidly connected to two distinct circuits. One of the circuits is illustrated in the schematic of FIG. **30**, which corresponds to the half of the cavity insert **440** delineated by line A-A in FIG. **29**. The other circuit (not shown in FIG. **30**) mirrors the one shown in FIG. **30** and the coolant inlet **445a** and outlet **445b** are both fluidly connected to both circuits. Each circuit includes a pair of first axial channels **445c**, a pair of transverse or cross channels **445d** and a pair of second axial channels **445e**. The coolant inlet **445a** is described by an axial slot **445a** through the spigot **443**, which extends from its end

face **443a** to the first internal shoulder **443b**. The coolant outlet **445b** is also described by an axial slot **445b** through the spigot **443**, similar to that of the coolant inlet **445a**, but is on the opposite side thereof. The coolant inlet **445a**, coolant outlet **445b** and radial holes **449** are spaced equally about the periphery of the spigot **443**, such that the radial holes **449** are between the coolant inlet **445a** and the coolant outlet **445b**. The flow path through each of the coolant inlet **445a** and the coolant outlet **445b** is orthogonal to the axis of the radial holes **449**.

The axial channels **445c**, **445e** are provided by blind drillings, which are spaced equally about the spigot **443** and body **441** and which extend from the end face **443a** of the spigot **443** to the cross channels **445d**. As illustrated most clearly in FIG. 29, the diameter of the first portion **446a** of the gate insert seat **446** is such that the portion of each of these drillings that extends from the end face **443a** to the first internal shoulder **443b**, opens into the first portion **446a**. The cross channels **445d** of each circuit are also provided by blind drillings that extend from a circumferential surface **441c** of the cylindrical body **441** toward respective ones of the flat sides **442**, such that they extend orthogonal to one another. The cross channels **445d** intersect each other and a respective pair of the axial channels **445c**, **445e** to provide fluid communication between the first axial channels **445c** and the second axial channels **445e**.

Referring now to FIGS. 31 to 33, the gate insert **450** is substantially cylindrical in shape with a first, nozzle tip receiving portion **451**, a second, molding cavity portion **452** and a third, gate portion **453** joining the first portion **451** to the second portion **452**. The first portion **451** includes a recess **451a** extending from an end face **451b** thereof, which is shaped to accommodate the tip of a valve-gated injection nozzle (not shown) and associated tip insulator (not shown) in the usual way. The first portion **451** also includes a circumferential groove **451c** in its outer, circumferential surface and spaced from the end face **451b** for accommodating an O-ring seal (not shown).

The second portion **452** describes a dome-shaped molding surface **452a** extending from an end face **452b** thereof, which is shaped to describe the outer surface of the base of a preform to be molded in the usual way. The second portion **452** also includes a circumferential groove **452c** in its outer, circumferential surface and spaced from the end face **452b** for accommodating an O-ring seal (not shown). The third portion **453** describes a central, cylindrical gate **453a**, which joins the recess **451a** of the first portion **451** to the molding surface **452a** of the second portion **452** in the usual way.

The diameter of the second portion **452** is smaller than that of the first portion **451** and the diameter of the third portion **453** is smaller than that of both the first and second portions **451**, **452**. The third portion **453** therefore provides a necked transition between the first and second portions **451**, **452**, thereby providing a circumferential cooling groove **454** therebetween. In addition, the third portion **453** also includes a circumferential bypass groove **455** recessed in the cooling groove **454**. In this example, the bypass groove **455** is narrower than the cooling groove **454**, such that a pair of shoulders **454a** are described in the base of the cooling groove **454**. As such, the cooling groove **454** provides a primary groove **454** and the bypass groove **455** provides a secondary groove **455** in the base of the primary groove **454**.

Referring now to FIG. 32, each retaining pin **460** includes a cylindrical body **461** with an externally threaded portion **462** and a plug portion **463**. The threaded portion **462** includes a driving end **464** with a hexagonal recess **465**

configured to receive a driving tool, for example a hex key (not shown). The plug portion **463** extends from the threaded portion **462** and includes a smooth circumferential surface **466** and a flat end **467**.

With reference to FIGS. 33 and 34, the network of cooling channels **413a**, **413b**, **413c** of the cavity plate **410** include a feed channel **413a**, which extends across the cavity plate **410** and parallel to the rows of seats **412**, and a series of branch channels **413b**, **413c**, which extend between each column of seats **412**, thereby joining the seats **412** in each column together in series. In FIG. 33, the branch cooling channel segment **413b** to the left of each seat **412** provides an inlet **413b** to the seat **412**, while the branch cooling channel segment **413c** to the right of each seat **412** provides an outlet **413c** or vice versa. In this example, the inlet **413b** and outlet **413c** are aligned at the same depth in the cavity plate **410** and are also in opposing sides thereof. It is also envisaged that the inlet **413b** and outlet **413c** may extend at an angle, e.g. a right angle, relative to each other.

The feed channel **413a** has a first diameter D_1 and the inlet **413b** and outlet **413c** have a second diameter D_2 , which is smaller than the first diameter D_1 . Each seat **412** of the cavity plate **410** comprises a stepped bore with a first, cavity insert receiving portion **412a**, a second, gate insert receiving portion **412b** with a smaller diameter than the first portion **412a** and a step **412c** providing a transition therebetween. The cavity plate **410** has a depth D , or thickness, as described from the front face CVF to the rear face CVR, which is substantially thinner than a conventional cavity plate (not shown).

The bodies of conventional cavity inserts (not shown) are received almost entirely within bores in such conventional cavity plates (not shown) such that most or all of their molding surfaces are within the plate, with cooling channels formed about the outer surface of each body which define pathways with the holes along which the cooling fluid flows. Contradistinctively, the cavity plate **410** of the mold **100** only receives the spigot **443**, such that the same cavity plate **410** may be used with different cavity inserts **440** for molding different preform designs. This also enables the cavity plate **410** thickness to be minimized. In this example, the first diameter D_1 is approximately half of the depth D and the second diameter D_2 is approximately one third of the depth D . This has been found to provide a cavity plate **410** having sufficient rigidity in operation, whilst minimizing the depth D . It is envisaged that, in some applications, the size of some of the cooling channels **413a**, **413b**, **413c** can be up to 75% of the depth D of the cavity plate **410** without detriment to its rigidity. However, it is preferred that the size D_1 , D_2 of the cooling channels **413a**, **413b**, **413c** is at most 60% of the depth D of the cavity plate **410**. It is also preferred that the size D_1 , D_2 of the inlet **413b** and outlet **413c** is at least 15%, more preferably at least 25%, of the depth D of the cavity plate **410**. It should also be noted that the cooling channels **413a**, **413b**, **413c** need not have a round cross-section, in which case the aforementioned sizes D_1 , D_2 may represent the dimension of the cooling channels across the thickness of the cavity plate **410**.

In addition, the molding surface **448** of the cavity insert **440** in this example is located entirely between the female taper **447** of the cavity insert **440** and the mounting face **441a** of the body **441**. However, the foregoing is not essential in every case as the location of this split-line may be affected by a depth of gate insert seat **446**, length of the spigot **443**, thickness of the cavity plate **410** as well as a shape and size of the base molding portion defined in the gate insert **450**. Suffice it to state that part of the molding

surface 448 could be received within the cavity plate seat 412. It is envisaged that up to one third, but preferably 10% or less, of the molding surface 448 could be received within the cavity plate seat 412.

As illustrated in FIGS. 28 and 33, the gate insert 450 is received within the stepped gate insert seat 446 of the cavity insert 440. More specifically, the molding cavity portion 452 of the gate insert 450 is received within the second portion 446b of the gate insert seat 446, with an O-ring (not shown) received within the circumferential groove 452c providing a seal therebetween. The end face 452b of the molding cavity portion 452 abuts the second shoulder 443c, such that the dome-shaped molding surface 452a provides an extension of the molding surface 448 of the cavity insert 440. The lower part of the nozzle tip receiving portion 451 is received within an upper part of the first portion 446a of the gate insert seat 446, with the circumferential cooling groove 454 aligned with the lower part of the first portion 446a of the gate insert seat 446 and with the base of the coolant inlet 445a and coolant outlet 445b. A cooling channel 454b is described between the circumferential cooling groove 454 and the facing surface of the lower part of the first portion 446a of the gate insert seat 446.

As illustrated in FIGS. 28, 34 and 35, each retaining pin 460 is received within one of the radial holes 449 of the spigot 443 of the cavity insert 440. The threaded portion 462 threadedly engages the threads of the radial hole 449 and the plug portion 463 extends inwardly of the spigot 443, into the circumferential cooling groove 454 and abuts the shoulders 454a. As such, the cooling channel 454b described between the circumferential cooling groove 454 and the first portion 446a of the gate insert seat 446 is divided into two segments or halves, wherein the plug portions 463 of the retaining pins 460 act as diverters. As illustrated more clearly in FIG. 35, the bypass groove 455 describes with the flat end 467 of the plug portion 463 a bypass flow channel segment 455a, which allows some flow to pass between the two halves of the cooling channel 454b. In addition to the aforementioned segmentation of the cooling channel 454b, the retaining pin 460 also retains the gate insert 450 within the spigot 443 of the cavity insert 440 to maintain the cavity assembly 430 in an assembled condition.

The cavity assemblies 430 are mounted to the cavity plate 410 by inserting the spigot 443 and projecting portion of the gate insert 450 of each cavity assembly 430 into one of the cavity plate seats 412. More specifically, the spigot 443 of each cavity insert 440 is received within the first, cavity insert receiving portion 412a and the upper part of the nozzle tip receiving portion 451 is received in the second, gate insert receiving portion 412b. O-rings (not shown) are received within the circumferential grooves 451c, 443d to providing sealed connection with the cavity insert seats 412 on either side of the inlets 413b and outlets 413c. Whilst not shown explicitly in the drawings, the end face 451b of the nozzle tip receiving portion 451 of the gate insert 450 is recessed slightly with respect to the rear face CVR of the cavity plate 410.

The cavity inserts 440 are oriented such that the flat sides 442 of the bodies 441 face one another along the vertical columns, as illustrated in FIGS. 27 and 33. In this orientation, the coolant inlets 445a and outlets 445b in the spigot 443 are aligned with the inlets 413b and outlets 413c in the cavity plate 410. The bolts 416 are inserted into the mounting holes 444 of the body 441 of each cavity insert 440 and threadedly engaged with the cavity mounting holes 415 to secure the cavity inserts 440 to the cavity plate 410. Torqueing the bolts 416 forces the mounting face 441a of the body

441 against the front face CVF of the cavity plate 410. Torqueing the bolts 416 also forces the end face 443a of each spigot 443 against the step 412c of the cavity plate seat 412, thereby closing off the upper end of the inlet 445a and outlet 445b and the drillings forming the axial channels 445c, 445e. As a result, the network of cooling channels 445 of each cavity insert 440 is sealingly connected to the network of cooling channels 413a, 413b, 413c of the cavity plate 410.

In use, cooling fluid flows from the feed channel 413a through the inlet 413b of the seat 412 into the inlet 445a of a first cavity assembly 430 in each vertical column. Most of the cooling fluid flows from the inlet 445a into the first axial channels 445c of each cooling circuit, through cross channels 445d, into the second axial channels 445e and out of the outlet 445b and into the outlet 413c of the seat 412. However, some of the cooling fluid also flows through the bypass channel segments 455a, which provides a more balanced flow through the cavity assembly 430 and simultaneously cools the region of the gate insert 450 surrounding the gate 453a. The cooling fluid then passes into the inlet 413b of the next seat 412 in the column and through the cavity assembly 430 received therein. It should be noted, however, that this is only one possible implementation. Other configurations of cooling channels 413a, 413b, 413c, 445 are envisaged without departing from the scope of this disclosure.

Indeed, it is expressly envisaged that the configuration of the bypass channel segments 455a may be varied, for example by one or more modifications to the bypass groove 455 or retaining pin 460. FIG. 36 illustrates one such variation in which each bypass channel segment 1455a lies adjacent the molding cavity portion 452 of the gate insert 450, such that only one shoulder 1454a is provided. The retaining pin 460 in the arrangement of FIG. 36 corresponds to that of FIG. 35. FIG. 37 illustrates another variation in which the bypass channel segments 455a, 1455a are omitted and the retaining pin 2460 includes a plug portion 2463 having a tapered end 2467. The tapered end 2467 cooperates with the circumferential cooling groove 454 to provide bifurcated bypass channel segments 2455a. Other arrangements are also envisaged and will be appreciated by those skilled in the art. For example, the cutaway provided by the tapered end 2467 may be replaced by a hole through the pin or some other arrangement.

FIGS. 38 and 39 illustrate an alternative cavity plate assembly 3400, which is similar to the cavity plate assembly 400 described above, wherein like features are labelled with like references with the addition of a preceding '3'. As shown, this cavity plate assembly 3400 differs, inter alia, in that the gate insert 450 is replaced with a two-part assembly, which includes a gate insert 3450 and a gate pad 3457. Each seat 3412 of the cavity plate 3410 includes a first, cavity insert receiving portion 3412a, a second, gate insert receiving portion 3412b with a slightly smaller diameter than the first portion 3412a and a tapered transition 3412c therebetween.

The gate insert 3450 includes a gate pad receiving portion 3451 in place of the first, nozzle tip receiving portion 451, which is longer and stepped to provide an enlarged end portion 3456 that abuts the end face 3443a of the spigot 3443 instead of the step 412c of the cavity plate seat 412 in the previous example. The gate pad receiving portion 3451 includes a frustoconical recess 3456a for receiving the gate pad 3457, which is tapered at an included angle of between 30 and 40 degrees, approximately 35 degrees in this example. The gate 3453a joins the receiving portion 3451

with the dome-shaped molding surface **3452a**. The enlarged end portion **3456** also includes a lip **3456b** adjacent the step, which lies adjacent the tapered transition **3412c** of the seat **3412** of the cavity plate **3410** in an assembled condition. The circumferential groove **3451c** is also on the outer, circumferential surface of the enlarged end portion **3456** for accommodating an O-ring seal (not shown).

The gate pad **3457** is hollow and describes the nozzle seat **3451a** therein. The gate pad **3457** includes a first, threaded end **3457a**, a second, frustoconical outlet end **3457b**, a flange **3457c** between the first and second ends **3457a**, **3457b** and a shoulder **3457d** between the flange **3457c** and the first end **3457a**. The flange **3457c** and the shoulder **3457d** both protrude outwardly. The flange **3457c** is hexagonal in this example for engaging an installation tool in use. As with the recess **3456a** of the gate pad receiving portion **3451**, the outlet end **3457b** is tapered at an included angle of between 30 and 40 degrees, approximately 35 degrees in this embodiment. The nozzle seat **3451a** terminates in the outlet end **3457b** of the gate pad **3457** at a central, cylindrical gate **3459** that forms an aperture through the tip of the outlet end **3457b**.

In an assembled condition, the threaded end **3457a** of the gate pad **3457** is received within, and in threaded engagement with, a threaded hole **3501** of the melt distributor **3500**, such that a nozzle tip (not shown) extends from within the melt distributor **3500** into the nozzle seat **3451a**. The hole **3501** of the melt distributor **3500** is stepped, with an enlarged pocket **3501a** at the end of the threaded hole **3501** within which the shoulder **3457d** is received. The shoulder **3457d** is annular and is sized to provide a tight fit with the pocket **3501** to maintain alignment of the gate pad **3457** relative to the melt distributor **3500**.

When the melt distributor **3500** is mounted to the cavity plate **3410**, the outlet end **3457b** of the gate pad **3457** is received within the gate pad receiving portion **3451** of the gate insert **3450**, with their gates **3453a**, **3459** aligned for receipt of molten material. This, split gate insert arrangement has been found to reduce wear that might otherwise occur due to misalignment between the nozzle tips (not shown) and gate inserts **450**. It also facilitates the separation of the melt distributor **3500** from a cold half (not shown) incorporating the cavity plate assembly **3400** without the need to allow the melt distributor **3500** to cool, thereby enabling faster mold changeover. The gate pad **3457** can be configured to be a sacrificial component, reducing the wear on the gate insert **3450** and extending its useful life.

As illustrated in FIG. 38, the combined depth of the spigot **3443**, gate insert **3450** and flange **3457c** is slightly less than that of the cavity plate **3410**, the reasons for which are described further below.

FIGS. 40 and 41 illustrate a partial section view through one of the mold stacks MS of the assembled cold half **130** illustrated in FIG. 2, with the mold stack MS shown in a molding configuration. In this, molding configuration, the top sealing surface of the preform is described in part by the top sealing surface portion TSS of the core insert **250** and in part by the neck rings **350**. The components of each mold stack MS are engaged with one another in what is commonly referred to in the art as a 'cavity-lock' design. The inner taper surfaces **355e** of the neck rings **350** surround the taper **253** of the core insert **250** and the lower surfaces **355d** of the flange portions **355b** of the neck ring **350** abut the front surface **251a** of the base **251** of the core insert **250**. In this example, the front surface **251a** provides an annular support surface **251a** which engages part of the flange portions **355b** of the neck ring **350**. The tapered side surfaces **355c** of the

neck ring **350** are received within the female taper **447** of the cavity insert **440** and the half-ring portions **355a** of the neck ring **350** abut the annular step **447a** or is otherwise spaced therefrom to define a narrow vent to allow air, during injection, to escape the molding cavity yet prevent outflow of molding material i.e. flash.

One significant difference from conventional molds is that the mold stack MS in this example has a stack height that is configured such that a clamping load CL applied, illustrated by the arrows in FIG. 40, applied to each of the core plate **210** and the cavity plate **410** (via the melt distributor **500**) is directed substantially entirely through the mold stacks. More specifically, the distance between the neck rings **350** and the core plate **210** is greater than the thickness of the stripper plate assembly **300** received therebetween, thereby preventing the clamping load CL from being directed through the stripper plate assembly **300**. In this example, this difference results in a clearance provided by a gap G between the stripper plate **310** and the core plate **210**. Whilst this arrangement is preferred, it is also envisaged that the gap G may be provided between the slides **320** and the stripper plate **310** in some variations.

Moreover, the mold stacks MS in this example are configured such that the clamp load CL applied therethrough is balanced. For example, the portions of the neck rings **350** that engage the cavity insert **440**, namely the tapered side surface **355c** and the radial end surface of each half-ring portion **355a**, have a similar projected area along the direction of the clamp load CL to that of the inner taper surface **355e** and the portion of the lower surface **355d** of the flange portion **355b** that engages the annular support surface **251a** of the core insert **250**. In this example, the mold stack MS is configured such that substantially all of the clamping load CL is transmitted through the tapered side surface **355c** and the radial end surface of each half-ring portion **355a**, and not between the flange portions **355b** of the neck ring **350** and the facing surface of the cavity insert **440**.

As will be apparent to those skilled in the art, substantially all of the clamping load CL passes through the mold stacks MS, providing a separate load path through each mold stack MS. This ensures a more even and predictable distribution of the clamping load CL across the mold **100**. Routing substantially all of the clamp load CL through the mold stacks MS can also eliminate the need for tonnage blocks and the need to tightly control the stripper plate **310** and bearing plate **315** thicknesses, as is required in conventional preform molds. Another consequence of eliminating the load path through the bearing plates **315** and stripper plate **310** is that the distribution and configuration of the bearing plates **315** is less critical, since they no longer play a role in distributing the clamp load evenly across the mold assembly **100**. As such, their number, distribution and manufacturing tolerances is less critical.

In addition and as explained above, the end face **451b** of the nozzle tip receiving portion **451** of the gate insert **450** is slightly recessed with respect to the rear face CVR of the cavity plate **410**. This ensures that most if not all of the clamping load CL is transmitted through the cavity plate **410**, avoiding any of the load being transmitted via the gate inserts **450**. In the case of the alternative cavity plate assembly **3400**, a similar effect is achieved by the aforementioned combined depth of the spigot **3443**, gate insert **3450** and flange **3457** being slightly less than that of the cavity plate **3410**.

It should be noted, however, that tonnage blocks (not shown) may be provided at predetermined positions between the core plate **210** and cavity plate **410** in order to protect the

mold stacks MS from inadvertent application of excessive clamping load CL. The skilled person will also appreciate that this clearance G need not be provided between the core plate 210 and stripper plate 310. Other configurations are possible without departing from the disclosure herein. One non-limiting example would be to dimension the core insert 250, neck rings 350 and cavity insert 450, such that they are in contact with small clearances between the other, surrounding components of the mold shoe.

The mold 100 may also be configured to protect the mold stacks MS from being over stressed. For example, the mold 100 may be configured such that only a portion of the clamping load CL is directed through the mold stacks MS if a predetermined threshold clamping load CL is exceeded. This can be achieved in this example by configuring the gap G such that a portion of the clamping load CL is directed through the stripper plate assembly 300 when the predetermined clamping load CL is exceeded. More specifically, the gap G may be configured such that, once a predetermined compression of the mold stacks MS is achieved, the gap G closes and a portion of the clamping load CL is directed from the neck rings 350 through the stripper plate assembly 300 to the cavity plate 410. More preferably, however, the mold 100 may include one or more columns, or tonnage blocks (not shown), between the core plate 210 and cavity plate 410 through which a portion of the clamping load CL is directed when the predetermined clamping load CL is exceeded.

With reference to FIGS. 42 and 43, the mold 100 enables a novel method of aligning the mold stacks MS of the mold 100. The method of aligning the mold stacks MS involves the following steps:

- i) assembling the cavity plate assembly 400 as outlined above, ensuring that the appropriate torque is applied to the bolts 416 to ensure that the cavity assemblies 430 are properly secured to the cavity plate 410;
- ii) assembling the stripper plate assembly 300 as outlined above, with the neck rings 350 mounted to the slides 320 in a floating manner;
- iii) assembling the core plate assembly 200 as outlined above, with the core plate 210 in an upright position on a substrate and ensuring that the bolts 218 are only loosely tightened, such that the core inserts 250 are mounted loosely to the front face CRF in a floating manner;
- iv) rotating the core plate assembly 200, such that its rear face CRR rests on the substrate;
- v) lowering the stripper plate assembly 300 onto the core plate assembly 200 to form the moving part 110 shown in FIG. 21;
- vi) rotating the cavity plate assembly 400 such that the cavity assemblies 430 are lowermost;
- vii) lowering the cavity plate assembly 400 onto the moving part 110 (see FIG. 42);
- viii) installing latches (not shown) to retain the core, stripper and cavity plate assemblies 200, 300, 400, or cold half 130, together, rotating the cold half 130, such that the rear face CVR of the cavity plate 410 rests on the substrate, and removing the latches (not shown);
- ix) lifting and lowering the core plate assembly 200 relative to the stripper and cavity plate assemblies 300, 400 (see FIG. 43) repeatedly, using appropriate lifting gear (not shown), in order to align the core inserts 250 relative to the neck rings 350 and cavity inserts 450;
- x) installing and torquing the coupling bolts 217 to engage with the coupling bolt holes 417 of the cavity plate 410, thereby securing the core plate 210 to the

cavity plate 410 and securing the mold stack MS in a closed configuration, starting from the innermost bolts 217 and working out;

- xi) torquing the bolts 218 from the rear side of the core plate 210 to secure the core inserts 250 to the core plate 210 in a fixed, aligned condition, in which they are immovable relative to the core plate 210 and aligned with the neck rings 350 and cavity inserts 450;
- xii) re-installing the latches (not shown) and rotating the cold half 130 to an upright position; and
- xiii) removing the coupling bolts 217 such that the cold half 130 is ready for installation.

In the above method, the cavity inserts 440 are the only stack components which are fixed in place initially. The neck rings 350 are secured to the slides 320 in a floating manner by virtue of the retainer mechanisms 351. Similarly, the core inserts 250 are initially mounted in a floating manner. As such, the lifting and lowering of the core plate assembly 200 in step ix) above causes the female tapers 447 of the fixed cavity inserts 440 to engage the tapered side surfaces 355c of the half-ring portions 355a, thereby aligning the neck rings 350 relative to the cavity inserts 440. In addition, the inner taper surfaces 355e of the neck rings 350 engage the core taper 253 of the core inserts 250, thereby aligning the core inserts 250 relative to the neck rings 350.

Whilst the rear-mounted bolts 218 provide a simple, yet effective means of fixing the core inserts 250, 1250 from their floating condition with the mold 100 in an assembled condition, other arrangements are envisaged. For example, the bolts 218 may be replaced by another fastening means, preferably one which is operable without access to the front of at least some of the core inserts 250, 1250. The fastening means may be operable either from the rear side of the core plate 210 or from some other accessible region (e.g. a side, top or bottom) of the mold 100 when it is in the assembled condition. Moreover and as indicated above, although the mounting surface 254 is free of any projections, the core insert 250 could be provided with a spigot that extends from the mounting surface 254 that is smaller than the seat 215 in the core plate 210 to enable some sliding movement therebetween. Indeed, in some examples the spigot may be substantially the same size as the seat 215 in the core plate 210.

It will be appreciated by those skilled in the art that the floating neck rings 350 may be replaced with conventional neck rings 350. The conventional neck rings (not shown) may be mounted loosely to the slides 320, such that they are free to float, for the duration of the aforementioned procedure. The neck ring bolts could then be torqued to secure them in place after the mold 100 is installed in the machine (not shown). Other configurations and approaches are also envisaged. For example, the procedure outlined in CA2741937 may be employed, wherein the cavity mounting holes 444 are aligned with mounting holes of the conventional neck rings (not shown) and some of the cavity mounting bolts 416 are omitted during the alignment procedure. This enables a tool (not shown) to be inserted through the cavity mounting holes 444 to torque the neck ring mounting bolts (not shown) before the coupling bolts 217 are removed at step xiii of the aforementioned alignment procedure.

It will be appreciated that the configuration of the elements of the molding system 100 may vary, particularly although not exclusively as described above. For example, whilst the annular support surface 251a of the core insert 250 is perpendicular to a longitudinal axis of the core, it may be angled or tapered. It may be particularly advantageous for

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the annular support surface **251a** to be angled or tapered, for example to provide a recess, e.g. a conical recess. This could be configured to provide an inward force to the neck rings **350** under the clamping load CL, for example to inhibit them from separating by the pressure of molten plastic during injection. This may be a shallow recess, for example angled less than 10 degrees. Moreover, the closed end of the core inserts **250** may be conical or any other suitable shape. The shape of the core cooling tubes **1270**, **2270**, **3270** may also be shaped to approximate such different shapes.

It will also be appreciated by those skilled in the art that several variations to the construction and/or use of aforementioned examples are envisaged without departing from the scope of the invention. It will also be appreciated by those skilled in the art that any number of combinations of the aforementioned features and/or those shown in the appended drawings provide clear advantages over the prior art and are therefore within the scope of the invention described herein.

The invention claimed is:

1. A preform cavity insert comprising a molding surface along its length, a substantially cylindrical body with flat sides to provide a substantially obround cross-section, a mounting face at or adjacent one of its ends for mounting the cavity insert to a cavity plate, and a spigot projecting from the mounting face for receipt within a seat of a cavity plate, wherein the spigot comprises a cooling channel inlet and a cooling channel outlet for fluid connection with respective cooling channel openings in the seat of the cavity plate, the cooling inlet being described by a first axial slot through the spigot, the cooling outlet being described by a second axial slot through the spigot, one or more cooling channels extending along and adjacent the molding surface, wherein the one or more cooling channels comprise a plurality of axial channels connected together by one or more transverse channels, and wherein the spigot further comprises a radial hole parallel to the flat sides of the body, the radial hole for receiving a retaining pin extending into a gate insert seat, wherein the radial hole and the cooling channel inlet and outlet are spaced equally about the periphery of the spigot such that the cooling channel inlet is on a first side of the spigot, the cooling channel outlet is on a second side thereof, opposite the first side and the axial hole is between the cooling channel inlet and outlet and orthogonal thereto.

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2. A preform cavity insert according to claim 1, wherein the cooling channel inlet is on a first side of the spigot and the cooling channel outlet is on a second side thereof, opposite the first side.

3. A preform cavity insert according to claim 1, wherein the gate insert seat is configured to receive a gate insert.

4. A preform cavity assembly comprising a preform cavity insert according to claim 3 and a gate insert received within the gate insert seat, wherein the gate insert comprises a cooling channel in fluid communication with the cooling channel inlet of the spigot for receiving cooling fluid therefrom, the assembly comprising a diverter for diverting, in use, cooling fluid from the cooling channel of the gate insert into the one or more cooling channels of the cavity insert.

5. A preform cavity assembly according to claim 4, wherein the cooling channel of the gate insert comprises a circumferential cooling groove which cooperates with a facing surface of the spigot seat and the diverter comprises a pin extending from the spigot into the cooling groove.

6. A preform cavity assembly according to claim 5, wherein the pin comprises one of a pair of opposed pins received within the cooling groove to separate the cooling channel of the gate insert into two segments, a first of the cooling channel segments providing a fluid connection between the cooling channel inlet of the spigot and one or more cooling channels of the cavity insert, a second of the cooling channel segments providing a fluid connection between the cooling channels of the cavity insert and the cooling channel outlet of the spigot.

7. A preform cavity assembly according to claim 6 comprising a bypass channel described between the pins and the gate insert which allows restricted flow from the first cooling channel segment directly to the second cooling channel segment.

8. A preform cavity assembly according to claim 7, wherein the circumferential cooling groove of the gate insert comprises a primary groove and the bypass channel is provided at least in part by a secondary groove in a base of the primary groove.

9. A preform cavity assembly according to claim 7, wherein the bypass channel is provided at least in part by a hole or cutaway in one or both of the pins.

10. A preform cavity assembly according claim 5, wherein the or each pin is threadedly engaged in a hole through the spigot of the cavity insert and serves as a retaining pin for retaining the cavity insert within the seat of the spigot.

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